Lubrication ENGINEERING

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

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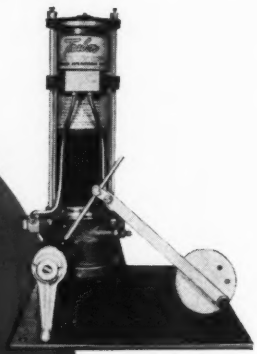

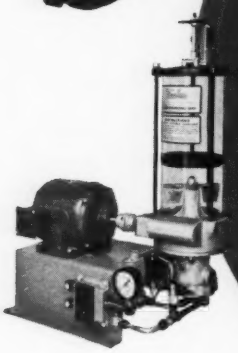

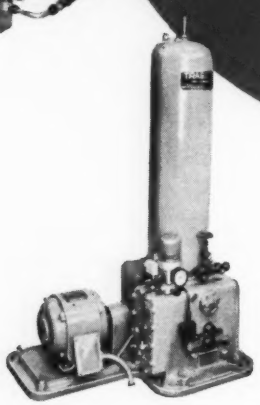

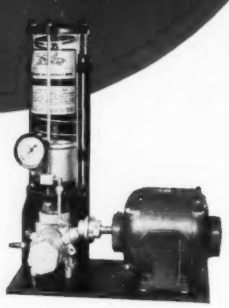

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Lubrication Engineering

VOL. 5 DECEMBER, 1949 NO. 6

In This Issue

The Editor's Page 263

Non-Flammable Hydraulic Fluids (Conclusion)—
C. M. Murphy and W. A. Zisman 264

Grease Symposium 270
(O. L. Maag—270; A. J. Jennings—270; Carl A. Berg—273; Geo. W. Miller—274; E. Ralph Harris—276; L. W. Deutsch—278; Morgan B. Lawton—278; J. H. Gustafson—281)

Viscosity-Temperature-Pressure Relationships of Lubricating Oils—
R. T. Sanderson 283

New Products and Equipment 288

Current Literature 290

News of the Sections 292

Section Officers 294

Book Reviews 296

Patent Abstracts, Oils and Lubricants 298

Subject and Author Index 306

Advertisers' Index 308

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Even though you may think he's not at work in *your* plant, it will pay you to be suspicious enough to make *sure*—for he's often well disguised.

HERE ARE SOME *QUICK CLUES*

Are you still using out-dated "paddle" methods to fill grease guns in your plant? There's a masked bandit!

You can save 3¾ man hours for every 100 lbs. of grease and eliminate contamination risks, too.

Are you depending on "hand and muscle" for machine lubrication—with manpower costs 'way out of line and hit-or-miss maintenance? That's sabotage, too!

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Have you ever measured your losses from "downtime" on machines due to bearing failure caused by faulty lubrication? Or have you ever figured the cost of "time-out" for lubrication? More thievery!

You can lubricate hundreds of bearings from one central point, with the right grease in the correct amount—while the machine continues to produce.

Have you got a clue that there may be a production thief in your plant—masked as faulty, old-time, hit-or-miss lubrication methods?

THERE IS A WAY TO STOP THESE LOSSES

An Alemite representative can tell you in 10 minutes how Alemite Methods will simplify and better organize your lubrication procedures. He can show you how mechanized lubrication from "barrel-to-bearing" will increase your production and profits.

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CIMCOOL COSTS LESS than old-fashioned cutting fluids because it lasts longer. It also cuts cost of cleaning and changing. It virtually eliminates rancidity and foul odors. And because of its low surface tension and low adhesion to work and chips, there is practically no carry off.

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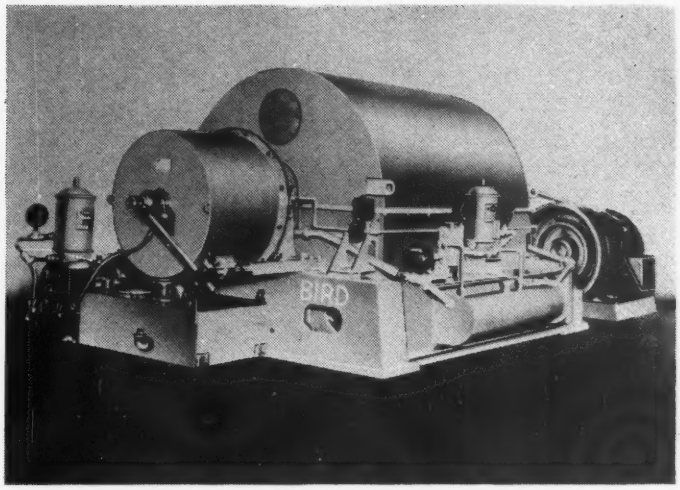
Bird Machine Co., South Walpole, Mass. planned on providing the Bird Continuous Centrifugal Filter with one pint of extra heavy oil a minute to each main bearing and five gallons a minute of a pressure lubricant to the gear drive. And to make sure of *always-clean* oil, they specified Cuno MICRO-KLEAN Filters—guaranteed not to pass any solids larger than specified, exclusively constructed for double dirt capacity and minimum pressure drop. (Primary filtering is done by Cuno AUTO-KLEAN Filters—all-metal disc-type).



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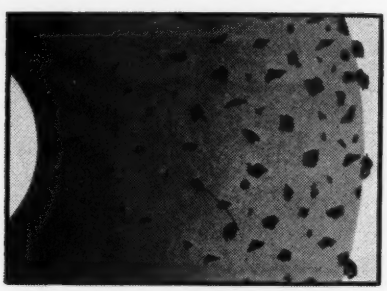

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Cuno is the only manufacturer of replaceable-cartridge filters *guaranteeing* to remove all solids larger than specified, plus a large proportion down to 1 micron. MICRO-KLEAN's exclusive "graded-density-in-depth" permits smaller particles to penetrate to varying depths, eliminates surface loading, *doubles dirt holding capacity*. Resinous impregnation and polymerization prevents channeling, rupturing, shrinking and distortion.

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Cuno MICRO-KLEAN filters come in varying densities . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

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MICRONIC • DISC-TYPE • WIRE-WOUND

MACHINES OF GREAT PERFORMANCE USE THE MOST DEPENDABLE OILING SYSTEM EVER DEVELOPED . . .

Foremen and machine operators know something significant that the "Front Office" may overlook, namely that machine performance is in direct relation to the quality of the oiling system.

The six models of Madison-Kipp lubricators meet almost every application requirement. They are used as original standard equipment on America's finest machine tools, work engines and compressors.

The end rotary drive twenty-four feed Model FD force feed lubricator illustrated is ideal for machine tool application.

Please address all inquiries to the home office in Madison, Wisconsin.

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One of the best-known automobile manufacturers selected Sunvis to lubricate three brand-new body-stamping presses. This equipment involved a big investment, and the company wanted the finest protection available.

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Because of performance like this, "Job Proved" Sunvis Oils are in wide demand wherever the finest lubrication is needed. They have high stability over a wide range of speeds, loads, and temperatures. You can count on Sunvis Oils for top performance and the surest protection of your machines. For full information call your nearest Sun Office.

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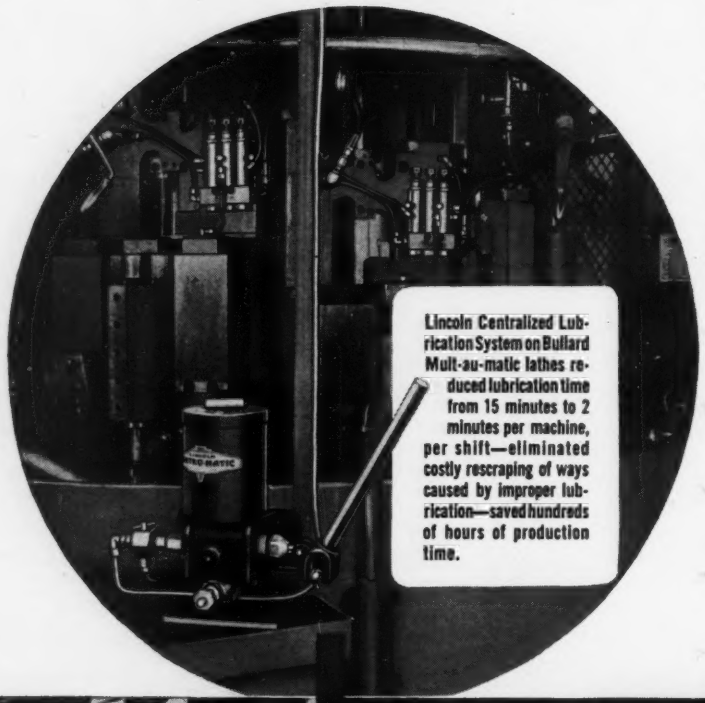
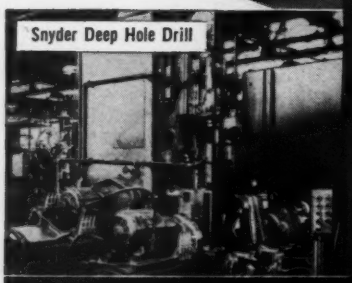
"Since Standardizing Lubrication Methods with *Lincoln* CENTRALIZED LUBRICATION SYSTEMS



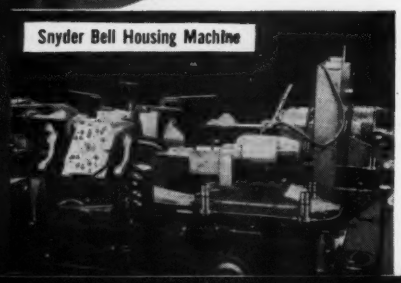
Lincoln Centralized Lubrication System on Bullard Mult-au-matic lathes reduced lubrication time from 15 minutes to 2 minutes per machine, per shift—eliminated costly rescraping of ways caused by improper lubrication—saved hundreds of hours of production time.

we eliminated many costly maintenance problems . . . saved production costs . . . and have not had a single case of machine failure due to lack of lubrication."

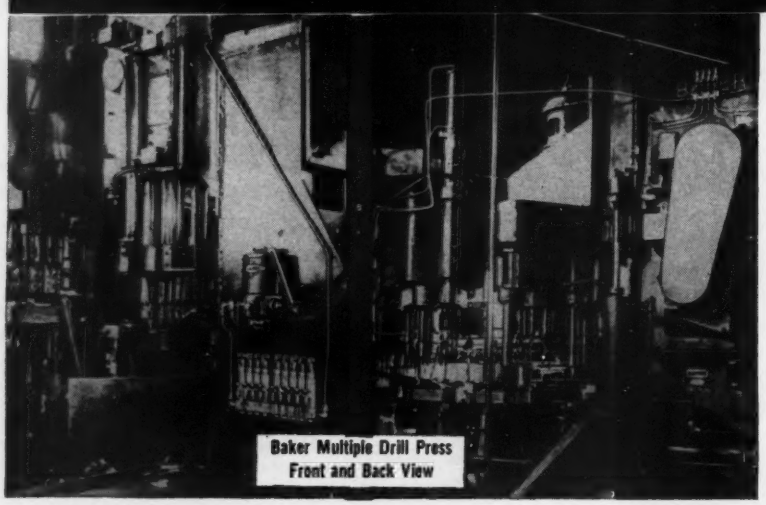
—As reported by the Master Mechanic of a prominent industrial manufacturer.



Snyder Deep Hole Drill



Snyder Bell Housing Machine



Baker Multiple Drill Press Front and Back View

Lincoln Centralized Lubrication Systems eliminate guesswork and old-fashioned methods. Instead, each and every bearing requiring grease or oil receives the right lubricant, in the right quantity, at the right time. Precisely measured shots of lubricant are delivered to every rotating, sliding, or reciprocating part at predetermined time intervals.

This company's Preventive Maintenance Program includes installation of Lincoln Centralized Lubrication Systems on the production machinery illustrated. Close manufacturing tolerances require extremely close fitted bearings on these machines necessitating measured applications of oil to all bearings at frequent, predetermined intervals.

Lincoln's lubrication specialists will work with you, and recommend the time and money saving Centralized Lubrication System to meet your requirements. Write for the name of your nearby Distributor.

Distributed Nationally Through Leading Industrial Distributors . . . Located in All Principal Cities.

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LINCOLN SAINT LOUIS
LUBRICATING EQUIPMENT • • •

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too much Solvent for Oil?

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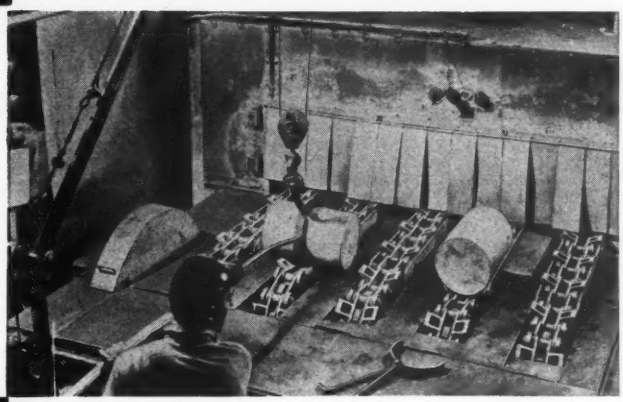
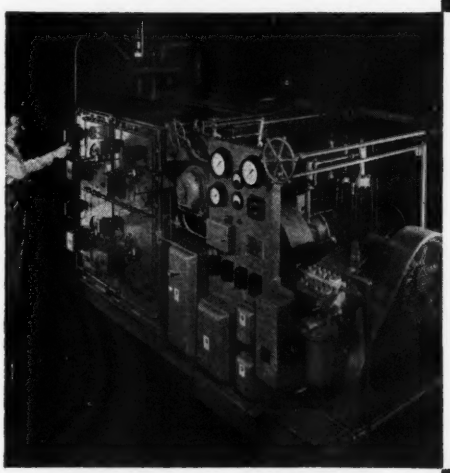


Right—*Link-Belt conveyor chains carry aluminum billets for annealing at 900°F. Ideal application for "dag" Colloidal Graphite.*



When you can lubricate once a month instead of twice a day, the savings are obvious.

"dag" Colloidal Graphite dispersions often make such savings possible where chemical conditions, rough service, or both extremes of temperature are the foes of easy movement.

Lubricating conveyors, ventilator fans, automatic plating machines, degreaser chains, chills, forging and stamping dies, are among 157 uses we can quote in which **"dag"** Colloidal Graphite has solved vexing maintenance or production problems.

If you'd like to see the growing list of 157 current uses, alphabetically arranged, just sign and mail the coupon.

Above—*"dag" Colloidal Graphite used for high temperature lubrication of screw threads on high pressure steam systems of Besler Corporation.*

Right—*Degreaser chains for conveying base castings of Hoover vacuum cleaners are lubricated with "dag" Colloidal Graphite.*

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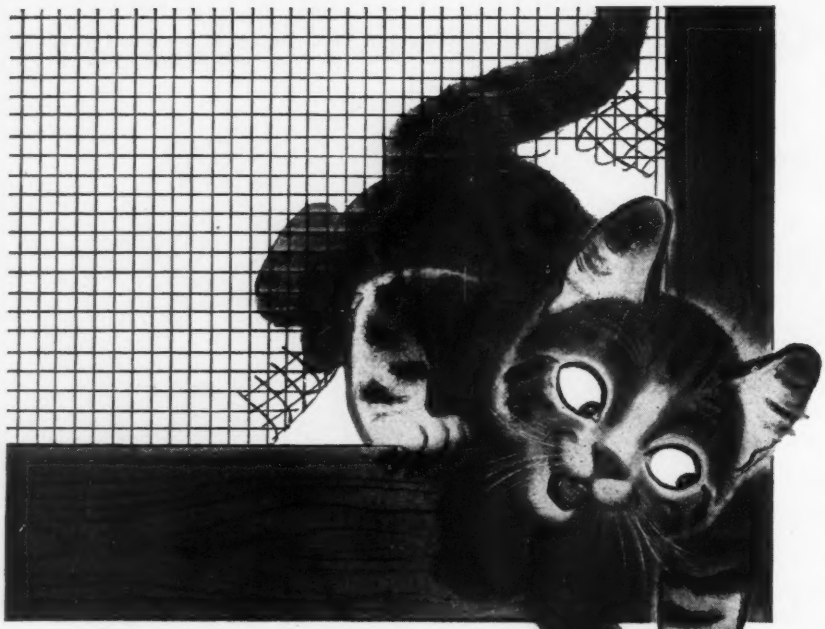

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Peak production . . . without worry of breakdown due to friction and wear . . . is made easier with Tycol high quality greases.

Made to "absorb punishment" without thinning down and dripping, Tycol greases avoid wasted lubricant, lost bearings and unnecessary down-time. These ultra-safe lubricants keep bearings . . . gears . . . shafts . . . friction-free and cool. They are available in grades with the proper "*PENETRATION" needed to give power a chance to produce with a minimum of waste.

Call your nearest Tide Water Associated office. Let them suggest the Tycol grease best suited to your needs . . . and remember, Tycol green cast greases are made from high quality cylinder stock and well refined neutral oil, with a minimum of soap — a maximum of oil . . . more efficient lubrication per pound of grease.

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THE EDITOR'S PAGE

An outsider looking at our country would probably envisage labor and management as bitter conflicting groups. We who are here know that these groups are not in real conflict, but under free enterprise each group is working to accomplish its desired objectives. In the minds of many of us the action of government in stepping into the picture to take over more and more authority at the expense of free enterprise is causing great concern. If carried too far, it could lead us to a paternalistic, socialistic state. There are many well-meaning people who actually think this should be the goal of government without stopping to think what this country has accomplished under our present free enterprise system, in spite of labor dictators and a few unscrupulous industrialists. Before joining the ranks of those fostering a change to paternalistic government, it might be well to consider a few statistics which were assembled in a little booklet published by Swift and Company and entitled "This Is Our Problem."

1. The United States has only 6% of the WORLD'S LAND.
2. The United States has only 7% of the WORLD'S POPULATION.
3. We have 85% of the AUTOMOBILES.
4. We produce 34% of the world's MEAT.
5. We have 50% of the HOSPITAL BEDS.
6. We have 92% of the world's BATHTUBS.
7. We have 52% of HIGH SCHOOL ENROLLMENT.
8. We have 48% of the RADIO SETS.
9. We have created 45% of the world's TOTAL WEALTH.

While all of us tend to be critical of others, sometimes a little self-appraisal is very much in order and in this connection your Editor was very much struck by an analysis which appeared in the *Advertising Placement Specialist* written by Walter A. Lowen and entitled "12 Real Reasons Persons Lose Their Jobs." Perhaps to most of us the job aspect may not be critical, but a self-analysis from the items suggested can well be taken to heart by everyone.

". . . It might help, however, if we look some valid reasons for being fired squarely in the eye. As one who has interviewed thousands of job-seekers, I can give you a dozen reasons for dismissal which the average employer will never tell you. These are:

Laziness—One may think he can soldier-on-the-job and get away with it, but profit-minded employers do not fire men whose production returns them a profit on their investment. "He profits most who serves best," applies to the employee as surely as it does to the employer.

Disloyalty—Elbert Hubbard once remarked: "An ounce of loyalty is worth a pound of cleverness." The disloyal employee is like the rotten apple in the barrel, spoiling all those around him. The wise employee refuses to listen to the man who bites the hand feeding him.

Intemperance—The intemperate man is unreliable. When most needed he is likely to let his employer down. In the business world, reliability is the "priceless ingredient," the cornerstone of progress as well as lasting success.

Poor Health—No employer can afford to tolerate frequent absenteeism. It works hardship on fellow-workers as much as it does employers. Poor health becomes intolerable.

Poor personality—Some people are born with charm; others must and can cultivate and acquire it. Without friendliness, tactfulness, magnanimity, a sense of generous cooperation one is likely to find himself out on a limb.

Emotional Instability—The person who is overly sensitive, who blows up under pressure, who fancies himself slighted and imagines unintended hurts—is an undependable employee who may be temporarily tolerated as a necessary evil but eventually rides for a fall.

Dishonesty—Dishonesty may take many other forms besides misappropriation of funds. A liar and a hypocrite is essentially dishonest. So is a malicious gossip and waster of time—of others' as well as his own. A truly honest man does not recognize temptation.

Immorality—The immoral person usually defends his immorality on the grounds of necessity, refusing to realize his responsibility toward his family, his friends, and his employer. Self-indulgence in immorality is generally recognized as a character weakness inducing failure.

Talkativeness—The man who talks too much quickly makes himself unpopular. A desirable employee, like a good actor, knows how to listen to, as well as deliver, a speech. Many a man has talked himself out of a job and never realized it. A wise man learns to be a good listener.

Bad disposition—The surly, arrogant, ungracious, vituperative employee may think he can vent his ill humor on his fellow-workers and get away with it, but when least expected—and more likely when least welcome—he will find himself on his way out.

Unprogressiveness—This is due directly to wrong thinking and has nothing to do with age. Inflexibility of mind and inability to change with the times can be manifested by the young, the middle-aged or the old. To succeed one must be mentally alert and progressive-minded, constantly striving for self-improvement.

Income mismanagement—The man who is always in debt, who borrows from everyone around him, who repeatedly asks his firm for an advance—in short, who makes it a habit to live beyond his means—may be tolerated for his brilliance, his good looks or his charm, but in the end his weakness of character in mismanaging his finances becomes glaringly apparent and he is replaced."

NON-FLAMMABLE HYDRAULIC FLUIDS*[1]

by C. M. Murphy
and
W. A. Zisman
Naval Research Laboratory
Washington, D. C.

SECOND OF TWO PARTS
(PART I *Published in* Vol. 5, No. 5—October, 1949 *Issue of* LUBRICATION ENGINEERING)

C. Glycols and Derivatives

A wide variety of glycols and glycol ethers have been studied in connection with the development of aqueous non-flammable fluids (18, 19). Flammability studies revealed that the glycols had S.I.T.'s ranging from 856 F for ethylene glycol to 687 F for tetraethylene glycol, while the oxygen demand ranged between 40 and 45%. During the incendiary fire tests on ethylene glycol only an occasional and extremely localized region of flame propogation was observed in the vicinity of the source of ignition. The methyl, ethyl, or butyl monoethers of ethylene glycol, diethylene glycol and also dimethoxy tetraethylene glycol all had oxygen demands of 12%. While the flash points of these glycols range from 230 F to 280 F, those of the glycol ethers are from 115 F to 285 F. Hence, the lower glycols are much less flammable than either ethers. All these materials cause difficulties due to their low flash points, low oxidation stabilities, hygroscopic nature (which causes problems of aqueous corrosion), low viscosity indices, and solvent action for the plasticizers in rubber packings (especially true for certain glycol ethers of low molecular weight). A variety of higher molecular weight glycols such as pentamethylene glycol, hexamethylene glycol, etc., are now available. Although the lower glycols and glycol ethers are not sufficiently flame-resistant to be used alone or with V.I. improvers to formulate the desired hydraulic fluids, they have much to recommend them when used with fire-quenching materials like water (20, 26).

Polymeric ethylene glycols like diethylene glycol, triethylene glycol, etc., and the homologous polypropylene and polybutylene glycols can be obtained with flash points above 300 F. However, the freezing points increase rapidly with the boiling and flash points (or degree of polymerization.) Branching the molecules by introducing iso alkylene units would lower the pour points and also adversely affect the V.I. The low V.I.'s of the n-alkylene oxide polymers are probably caused by hydrogen bonding between terminal —OH groups. This can be decreased by "chain stoppering" one or preferably both terminal hydroxy groups with an alkyl group using an ester or ether linkage (27). This approach has been used in the mono and di-ethers of polymers of ethylene and propylene glycols which are available in a number of types and viscosity grades. Many of their properties have been described in publications since the war (28, 29, 30, 31, 32, 33, 34). An investigation of several classes identified as LB and HB fluids was made at NRL (18, 19, 35) with emphasis on the possibilities of the water-soluble HB fluids for military hydraulic fluids and of the nearly water-insoluble LB fluids for low temperature automotive and aircraft engine oils. The need for rust inhibition was established and numerous polar type rust inhibiting compounds were developed (6, 7).

In the pure form these fluids oxidize appreciably in a week at 150 F. They are readily and effectively stabilized with various common antioxidants. When stabilized with the antioxidant recommended by their manufacturer, the commercial fluids have flash points of approximately 325 F for a fluid of 10 cs. at 100 F to 490 F for fluids having viscosities above 65 cs. at 100 F. Their fire points range from 375 F to 600 F. The S.I.T. ranges from 720 F to 750 F, while the oxygen demand is 54% for the more viscous grades decreasing rapidly to 20% at a viscosity of 10 cs. at 100 F. Incendiary fire tests have demonstrated that these fluids had ignition properties quite like those shown by ethylene glycol. Not only are these fluids good lubricants but they have low hardening or swelling effects on most rubber packings (33, 34). As the oxidation products are either volatile or are dissolved by the fluid, difficulties with sludge formation are rarely encountered.

Their use in aircraft hydraulic systems have been limited because fluids having viscosities of 10 cs. at 130 F have viscosities at —40 F of approximately 10,000 cs. The viscometric characteristics can be improved without impairing their flammability properties by blending with high boiling diesters (36). For example, the viscosity at —40 F of the LB-140 grade fluid is reduced from 30,000 cs. to 5500 cs. while that at 130 F is only reduced from 18.1 to 10.1 cs. by dilution with 40% by weight of di-(2-ethylhexyl) adipate. The flash point and S.I.T. of the blend were the same as those of the undiluted LB-140 fluid and the oxygen demand of the blend was above 50%.

Realizing the need for less flammable fluids during the war, the producer prepared a blend identified as fluid "H" of 27% by weight of the HB fluid (Grade 5100) and 73% by weight of triethyl phosphate, which conformed to the viscometric requirements of AN-0-366. This blend was prepared to demonstrate the viscometric possibilities and to determine its flammability characteristics. The flammability properties given in Table II reveal that the flash point is roughly 100 F above that of the AN-0-366 fluid; the S.I.T. is approximately 300 F higher; and the oxygen demand of 55% indicates that it will be resistant to oil mist explosions. Though this fluid is much less flammable than the petroleum base hydraulic fluid it causes excessive swelling of common packings because of the presence of the phosphate ester in the blend.

D. Silicones

In the hydraulic range of viscosities the high boiling points, low freezing points, high viscosity indices and oxidation stabilities of the silicones make them especially promising materials. This led to studies of their oxidation stability (37, 38, 39, 40) flammability (18, 19, 20), behavior in hydraulic systems (38, 41) lubricating properties in journal bearings at ordinary and high temperatures (42, 43) rust preventive properties (6, 7),

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[1]The opinions or assertions contained in this paper are the authors' and are not to be construed as official or reflecting the views of the Navy Department.

* Paper presented at 4th Annual Convention of A.S.L.E., New York City, April 12, 1949.

and viscosities up to 700 F (27). It was shown that by properly stripping off the more volatile fraction, the oxygen demand was raised to 50% for silicones having viscosities over 20 cs. at 100 F (18, 19, 38), and such fluids were proved to be non-flammable in incendiary fire tests. Producers later adopted the practice of stripping the silicones in the final manufacturing stages. No fire points were obtained in the usual sense, but after prolonged heating at temperatures of 500 F, enough cracking with the evolution of volatiles took place to allow ignition of a flickering easily extinguished yellow flame. The S.I.T.'s were from 500 F to 600 F; 860 F to 900 F; and 900 F to 990 F for the ethyl-, methyl-, and methylphenylsilicones respectively. Hence, the stripped silicones are much less flammable than petroleum oils of comparable viscosities, and though they do not resist all five flamability tests they are unusually flame resistant.

Silicone fluids irritate the eyes on direct contact, but otherwise they appear to be non-toxic and non-irritating. Once ignited, they evolve a dense and irritating vapor containing minute particles of silicon dioxide. Effects on standard O-ring rubber packings (14) are minor at ordinary temperatures, but as temperatures rise above 140 F increasing troubles are encountered because of shrinkage and hardening. Associated with their abnormally low surface tensions (19 to 20 dynes per cm. as compared with approximately 30 for petroleum hydraulic fluids) is the ability of the methyl silicones to creep readily over metal surfaces and through mechanical joints. Hydraulic bench tests revealed the necessity of being careful about the tightness of joints, and the use of pipe dopes was found advisable (41). The various types of silicones are not compatible with petroleum oils. In Table III are given comparative viscometric data to show that a single methyl silicone fluid can care for the viscosity requirements of all present military hydraulic fluid specifications (38, 41). Despite their limited flame resistance, their restrictive lubricating properties, and their present high price, the silicones have outstanding advantages for extreme temperature hydraulic use.

chlorinated diphenyls (Arochlors), and diphenyl ethers (Dowphens) as well as perchlorethylene. The earlier flammability study (18, 19,) revealed that at least 30% of the hydrogen atoms had to be replaced by halogen atoms to obtain adequate resistance in all five flammability tests. But the difficulty of preparing highly chlorinated compounds increases greatly with the molecular weight and complexity of the compound. This is in part due to steric hindrances caused by the much larger size of the chlorine atom than the hydrogen atom.

A serious objection to using many of the available chlorinated hydrocarbons and ethers in hydraulic systems is their tendency to hydrolyze with the evolution of hydrochloric acid. Comparative data on the extent of hydrolysis of numerous commercial and laboratory preparations of interest in hydraulics were obtained between 1942 and 1944 (44, 45). The rate of hydrolysis is small in compounds in which chlorine is directly attached to an aromatic hydrocarbon ring, but it is much greater when chlorine is attached to aliphatic carbon atoms especially if both chlorine and hydrogen atoms are attached to the same carbon atom. Hydrolysis measurements for hydraulic or lubrication applications should be made in contact with metals generally found in the system, i.e., steel, copper alloys and duralumin (45). In many instances the compounds studied were not adequately stable because of the hydrolysis of unstable impurities. Resistance to atmospheric oxidation was good for many compounds, the least satisfactory being perchlorethylene and hexachlorobutadiene. However, this difficulty was avoided by the addition of common antioxidants. Arochlors 1242 and 1248 were sufficiently flame-resistant to the incendiary fire, spray flammability, and spontaneous ignition tests, but the flash points were only 350 F and 380 F, respectively. All of the highly chlorinated materials were non-flammable but attacked the commonly used rubber packings, the aromatic compounds being the worst.

The chlorinated compounds studied evolve fumes when overheated or ignited and these probably are health hazards. The generation of phosgene from the

TABLE III

COMPARISON OF THE VISCOMETRIC PROPERTIES OF A METHYL SILICONE WITH THOSE OF MILITARY SPECIFICATION HYDRAULIC FLUIDS

Viscosity Requirement	*Specification*			*Methyl-Silicone*
	51-*F*-23 (*Ord*)	51-*F*-21 (*Ord*)	*AN*-0-366	
Cs. at 210 F (Min)	8.0 Min.	10.0 Min.	5.1*	18.4
130 F (Min)	25.*	20.*	10.0 Min.	34.3
100 F (Min)	40. Min.	27. Min.	14.*	44.9
0 F (Max)	1500. Max.	215. Max.	94.*	160.
–25 F (Max)	7500. Max.	600. Max.	220.*	250.
–40 F (Max)	.....	.....	500. Max.	355.

*Viscosity of a typical oil but not a specification requirement.

A more flame resistant and oxidation stable liquid polymer would be the trifluoromethyl substituted polysiloxanes. This homologue of the polymethylsiloxanes would not be expected to pyrolize or oxidize to produce combustible methane or its derivatives, but would generate less flammable fluorinated methanes and derivatives. Many attempts have been made to prepare this polymer but without success.

E. Chlorinated Compounds

The scientific literature shows that much has been done in developing halogenated organic compounds for use as heat transfer fluids, refrigerants, dielectrics, dry cleaning fluids, and fire-fighting liquids. Well known examples are carbon tetrachloride, the various

reaction of $C\,Cl_4$ and steam is well known and is a reason for caution in fighting fires in the vicinity of chlorinated aliphatic compounds. Extensive toxicological investigations have been made on the chlorinated aliphatic hydrocarbons (46, 47, 48), but there appears to be a dearth of information concerning the chlorinated aromatic compounds. The viscosity indices of the highly chlorinated compounds are extremely low, while the liquidus range for most compounds is not wide enough for many extreme temperature applications. Despite these difficulties the incorporation of V.I. improvers to low viscosity, highly chlorinated liquids, the addition of antioxidants, acid acceptors to combine with any small amounts of hydrolytic acid, rust inhibitors and wear preventives make possible the de-

TABLE IV
COMPOSITIONS OF EXPERIMENTAL "CONTROLLER" FLUIDS

Controller Oil PS*

Component	*Wt. %*
Arochlor 1248	57.2
1, 2, 4-Trichlorobenzene	24.5
Perchloroethylene	9.1
Polystyrene (12,000 mol. wt.)	9.2

Controller Oil CC**

Chlorinated cumene (Isopropyl benzene)	78.0
Perchloroethylene	13.75
Polybutene (B-12)	8.25

*0.05% Paranox 512 and 0.02% Paranox 213 added to stabilize the fluid to oxidation and inhibit rusting.
**0.05% Paranox 213 used instead of 0.02% as in PS.

velopment of useful hydraulic fluids and lubricants.

In 1941 and 1942 the Bureau of Ships contracted for the development of a non-flamable ship hydraulic fluid. Two liquids were developed which are identified as "Controller Oil CC" and "Controller Oil PS." One of these has been described in a patent (49) and compositions of both are given in Table IV. Some interesting properties of these fluids are given in Table V and for comparison, there are included the requirements of the then existing Navy specification OS 1113 for a high V.I. petroleum hydraulic oil and also Specification 51-F-21 developed later by the O.S.R.D. (15) for ship use. Controller Oil PS was found non-flammable in all five flammability tests while the CC fluid, though having a flash point, was relatively non-flammable. Both fluids were satisfactory as regards laboratory measurements of hydrolysis, oxidation and corrosion inhibition. These fluids were never used because of their rapid attack on rubber packings and because they were considered too toxic for general Naval use except in non-leaking systems or under conditions of ample circulation of air. Equally satisfactory non-flammable hydraulic fluids in a variety of viscosity grades could be produced by obvious modifications in these compositions.

Hexachlorobutadiene was made available in commercial pilot plant quantities late in the war and its flammability properties were studied thereafter (18, 19). Recently there has been placed on the market a non-flammable hydraulic fluid "A" for aircraft, based on the use of a hexachlorobutadiene and additives (50), having the properties listed in the last column of Table II. Flammability measurements show that this fluid is practically non-flammable to the fire hazards that may be encountered by commercial and military aircraft. It is miscible with petroleum-base fluids but there is some uncertainty as to the toxicity in ordinary use or during overheating. The fluid is reported to attack some rubber packings but to be satisfactory with others (50).

The kinematic viscosities show it does not have as good viscometric properties as required by Specification AN-0-366; however, the absolute viscosities of the two fluids are not greatly different because of the much greater density of the chlorinated fluid. It is reported (50) that the fluid performed satisfactorily in a 3000 psi hydraulic system operating at 160 F. No information as to shear stability, and antiwear properties or condition of the oil after the test are yet available.

The rust inhibition properties were determined by the static water drop test at 140 F with distilled water. No rusting was observed but the metal test specimen was stained at the points of contact with water. This may be due to hydrolysis. Considerable material precipitated during the static water drop test, probably additives. These properties need investigation as it is impossible to prevent moisture from entering all hydraulic systems. The corrosiveness of the bulk oil to metals common to hydraulic systems was investigated by immersing specimens in the oil for 72 hours at 212 F. No evidence of corrosion or pitting was observed.

The wide use of existing chlorinated liquids in hydraulics will depend on the development and adoption of suitable packings and the observance of the proper health precautions. More research is undoubtedly needed on the synthesis of new liquids, the toxicology of chlorinated compounds, and on the physical chemistry of the fire-quenching properties. In general, halogenated fluids for aviation uses represent a weight problem due to their high densities. This has been considered a serious limitation by aircraft designers and operators.

F. Fluorinated Compounds

Research programs on the synthesis and properties of organic compounds of fluorine were sponsored by

TABLE V
COMPARATIVE PROPERTIES OF EXPERIMENTAL CONTROLLER OILS AND ORDNANCE SPECIFICATION HYDRAULIC OILS

	Controller Oil		*Navy Specification*	
	PS	*CC*	*O. S.* 1113*	51-*F*-23
Specific Gravity 60/60 F	1.43	1.29	c. a. 0.85	c. a. 0.85
Flash Point, F (C. O. C.)	None	350	310	300 (Min)
Fire Point, F (C. O. C.)	None	460	350	325
S. I. T., F (a)	> 1000	> 1000	650.	c. a. 500.
Oxygen Demand, %	59	34	14–16	12–14
Viscosity, cs. at 210 F	7.8	11.8	8.2	8. (Min.)
130 F	23.	27.	24.	25.
100 F	41.3	41.8	46.8	40. (Min)
0 F	900.	340.	2000.	1150. (Max)
–10 F	1405.	500.	3920.	2000.
–25 F	3100.	950.	13000.	7500. (Max)
–40 F	.....	2186.	.....	.....
Viscosity Index	148	172	135 (Min)	150–160
Pour Point, F	–40	–85	–40	–40 (Max)
Copper Strip Corrosion, 3 hrs. at 212 F	Unchanged	Unchanged	Unchanged	Unchanged
Corrosion Test, 96 hrs. at 212 F—				
Cold-rolled Steel	Unchanged	Unchanged	Unchanged	Unchanged
Copper	Light Stain	Light Stain	Slight Stain	Slight Stain
Brass	Severe Stain	Unchanged	Severe Stain	
Aluminum	Unchanged	Unchanged	Unchanged	Unchanged
A. S. T. M. Turbine Oil Rust Inhibition Test	Passes	Passes	Fails	Passes
Inhibition Test	Passes	Passes	Fails	Passes

*Typical properties of a petroleum hydraulic oil conforming to specification OS1113 of 1941.
(a) Method of Sortman, Beatty and Heron 16).

the O.S.R.D. and the Navy during the war, and interest in the subject has continued to increase. The reactions and properties of the compounds formed are of theoretical interest because fluorine is the lightest halogen and the most electronegative of the elements. The new compounds prepared were studied as possible poison gases, insecticides, dielectrics, plastics, anesthetics, stable heat transfer fluids and non-flammable lubricants and hydraulic fluids. The latter applications directed emphasis toward completely fluorinated hydrocarbons (perfluorocarbons). Such compounds are more stable than chlorinated hydrocarbons because of their high energy of bonding to carbon and the smaller atomic radius of fluorine than chlorine. Valuable summaries of the chemistry and properties of fluorinated hydrocarbons have been presented by Smith (51), Simons (52), Grosse and Cady (53) and Fowler et al (54).

Although relatively few pure perfluorocarbons are available in quantities exceeding 100 ml., enough properties have been studied to permit some generalizations of interest. Substitution of fluorine for chlorine lowers the boiling point about 75 F and also raises the freezing point, hence it is difficult to find fluorocarbons with a wide enough liquidus range for most lubrication and hydraulic uses. Perfluorinated compounds have much larger temperature coefficients of viscosity than the analogous hydrocarbons and the higher boiling compounds are usually incompatible with them. As with the analogous chlorinated compounds, substitution of fluorine on aromatic carbon atoms is much more stable to hydrolysis than on aliphatic carbon atoms. Where an aliphatic carbon atom has attached to it both hydrogen and halogen atoms, instability to hydrolysis can be predicted. The group ($—CF_3$) is remarkably stable and often exerts a stabilizing effect on the adjacent carbon atom. Only when perfluorinated are the aliphatic hydrocarbons stable to hydrolysis. Though the high boiling perfluoro compounds are stable, it is usually difficult to eliminate unstable impurities. Consequently, as for the chlorinated compounds, the test for stability to hydrolysis in the presence of common metals and their oxides is a necessity for application, production control and specification purposes (45). Lists of the highly fluorinated hydrocarbon compounds prepared through 1947 are given in several survey papers (51, 53, 54, 55, 56). The number of fluoro-compounds has risen rapidly since.

By analogy with the development of fluids "CC" and "PS" (49), it is evident that mixtures of partially fluorinated isopropyl benzene and diphenyl could be used with similar additives to develop non-flammable hydraulic fluids. However, the fluorinated compounds are more volatile than their chloro analogs. The fluorocarbon analog to hexachlorobutadiene, being a gas at room temperature, is unsuitable as a base stock for nonflammable aircraft hydraulic fluids.

The perfluorinated petroleum oils and polymonochlorotrifluoroethylene fluids which were developed by O.S.R.D. during the war (55, 57, 58) are now produced commercially on a small scale. Some pertinent properties of these fluids as well as those of perfluorinated dibutyl ether and tributyl amine are given in Table VI. All of the compounds listed in Table VI have S.I.T.'s above 1100 F, oxygen demands greater than 85%, and no flash points were observed up to their boiling points. Therefore, they would be expected to be non-flammable to the various hazards to which they may be exposed. Other perfluorinated compounds should have similar flammability properties. The V.I.'s are given where they can be computed, and it will be noted that they are negative. The perfluoro ether is much too volatile and too low in viscosity for hydraulic applications. While the perfluorinated petroleum fraction FCD-329 and the tributyl amine are less volatile, the very high viscosity-temperature coefficient of the latter, (due to its symmetrical structure) and the limited solubilities of both fluids for additives and V.I. improvers make it difficult to prepare suitable products for hydraulic and lubricant applications. The other fluids show a progressive decrease in volatility and rise in pour point with increasing viscosity. Though the high pour points may limit the temperature range of application, these fluids may prove useful as base fluids for high temperature hydraulic applications. All but the low molecular weight perfluorocarbons are limited as lubricants and hydraulic fluids by their high viscosity-temperature coefficients, high pour points and low solubilities for additives. The high densities of these fluids are disadvantageous in areonautical hydraulic applications.

Despite the limitations of available fluids, it should not be assumed that more suitable ones cannot be developed. Several considerations deserve attention of synthetic chemists in preparing fluorinated lubricating and hydraulic fluids of higher V.I., lower pour point, and higher boiling point. It is essential to recognize that liquid polychlorotrifluoroethylene depends, in part, for its liquidus range on hindrances to the freezing or close alignment of neighboring molecular chains caused by the large chlorine atom projecting from each monomer. More hindrance to freezing is desirable, and polymers of perfluoro propylene having a trifluoro methyl side-chain on each monomer would be more suitable since that is the shortest possible side-chain which is chemically inert. Similar polymers of the perfluoro butenes are of promise although some de-

TABLE VI

PROPERTIES OF SOME COMMERCIALLY AVAILABLE PERFLUORINATED COMPOUNDS

	Fluorinated Petroleum Oil Fractions			*Polychlorotrifluoroethylene*		*Perfluorodi-*	*Perfluorotri-*
	FCD-329	*FCD-330*	*FCD-331*	*"F S"*	*"S"*	*butyl ether*	*butyl amine*
Density, 77 F	1.91	1.97	2.04	1.89	1.95	1.71	1.83
Boiling Point, F	266-356 at 760 mm	122-266 at 10 mm	266-302 at 10 mm	200-300 at 10mm	240-260 at 0.3 mm	212 at 760 mm	352 at 760 mm
Viscosity, cs. at 210 F	0.63	1.29	3.28	1.00	5.61	0.28	0.57
130 F	1.30	3.58	17.16	2.2	31.7	0.44	1.23
100 F	1.80	6.26	49.0	3.34	86.9	0.55	1.84
32 F	5.4	54.	5240.	14.	2690.	1.0	8.2
0 F	12.2	297.	Below pour pt.	41.9	Below pour pt.	1.45	30.0
–20 F	24.	1600.	....	106.	....	1.9	90.
–40 F	54.6	14500.	....	359.	....	2.64	405.
Viscosity Index	....	–213	–690	–81	–178	....	....
Pour or Freezing Point, F	<–70	–45	>0	<–70	>0	<–70	–26*

*Freezing Point—Pour Point was below –70 F but on storage it crystallized.

crease in V.I. would result if many perfluoro ethyl side-chains are formed. Obvious variations are possible by substituting chlorine for fluorine atoms; however, this cannot be carried far because the larger chlorine atoms create much hindrance to free rotation and chain coiling (27). Of course, control of chain length is necessary to prevent the polymeric reaction going all the way to the formation of a plastic solid.

Another promising approach is through the formation of perfluorinated alkyl ethers or polyethers with trifluoromethyl side chains attached to the alkyl groups. Such compounds can be considered as analogous to the polyalkylene glycol ethers like the LB fluids. The advantage of such ethers is that the periodic interruption of the aliphatic carbon chain by oxygen atoms will act to prevent the building up of stresses between adjacent close-packed CF_2 groups and so decrease steric hindrances to free rotation about the carbon-carbon bonds. A high V.I. fluid would be expected to result if polymerization were controlled. An analogous approach is to interrupt the main carbon chain with other atoms like sulphur having a covalence of two. The perfluoro polyethers should be stable to atmospheric oxidation since perfluoro dibutyl ether has been reported to be remarkably stable.

A third approach recommended is through the formation of perfluoro mixed tertiary amines. The V.I., and pour point of perfluoro tributyl amine could be improved by preparing perfluorinated dibutyl methyl amine. Compounds with a wider liquidus range would be perfluorinated dilauryl methylamine or dilauryl ethyl amine. Inasmuch as the perfluorotributyl amine is reported to be very stable the proposed mixed amines can be expected to prove stable also.

From this brief survey of a rapidly growing field of chemistry, it can be concluded that no fluorinated hydrocarbons or other compounds of fluorine are now known which are more suitable for hydraulic fluids than the existing chlorinated fluids. However, promising approaches exist and further research is needed.

G. Aqueous Solutions

Water is an effective, cheap and stable fire-quenching material. Early war research at NRL was concerned with the effect of water in decreasing the flammability of various organic freezing point depressants (18, 19). When over 35% of water was present many of these fluids were non-flammable. Ethylene glycol was selected as the most suitable for developing a water-base hydraulic fluid because it is one of the most efficient freezing point depressants; it is produced in large volume; it is free from deleterious effects on common packing materials; it has a viscosity at 100 F of only 8.7 cs. permitting the use of V.I. improvers, and it has an oxygen demand of 40% and a S.I.T. of 856 F. Only when practically all of the water has been boiled off can such solutions support combustion. In fact, a 35% glycol-water solution is a good emergency fire-fighting fluid for use at subzero temperatures in the Arctic or at high altitudes.

Lubricating properties of such solutions were increased considerably by the addition of a linear water-soluble polymer and a mild, thin-film, wear preventive. As the variety of metals present in the hydraulic system is increased and as the requirements are lowered for the pour point, the problem of improving lubrication properties become difficult. Corrosion inhibition of aqueous hydraulic fluids for aircraft is more difficult than for engine antifreeze solutions because of the greater variety of metals present. An additional problem is encountered with interference between many corrosion inhibitors and wear preventives. In the construction of aircraft hydraulic systems steel is replaced largely by aluminum (52 SO or 24 ST duralumin), and zinc-plated steel and cadmium-plated steel are often employed to decrease electrolytic corrosion. Some aircraft components are made of high magnesium alloys, and this makes the inhibition problem more complex.

TABLE VII
COMPOSITION OF HYDROLUBE U-4

Component	*Wt. %*
Ucon 75H—90,000 polymer	9.1
Ethylene glycol	38.7
Water (distilled)	37.1
Butyl "Cellosolve"	10.0
Hexamethylene glycol	2.0
Diamylammonium laurate	1.0
Diisopropyl ammonium nitrite	1.7
Sodium 2-mercaptobenzothiazole	0.2
Salicylal ethanolamine	0.2
Total	100.0%

Polymer-thickened, inhibited, glycol-water solutions prepared for hydraulic and lubricating uses have been under development at the Naval Research Laboratory since early 1943 and have been given the generic name "Hydrolubes." A letter is suffixed to indicate the type of polymer used. Improved fluids and variations for special purposes are also under development in industrial laboratories. The progress of research through 1946 at the Naval Research Laboratory has been described in two administrative reports (20, 26). It is planned to publish elsewhere a full account of the results of this investigation. Hydrolubes U and A, developed in 1945, were superceded in 1946 by Hydrolube U-4 which has received the greatest amount of bench and flight testing. The composition of Hydrolube U-4 is given in Table VII and some of its properties are summarized in Table II.

Hydrolube U-4 performs satisfactorily in present hydraulic systems; however, the average pump life varies with the design. Pesco gear pumps can be operated for thousands of hours at 140 F and 3000 psi, and the New York Air Brake pumps, if modified by cadmium plating of the helical springs, also operate satisfactorily under these conditions of pressure and temperature. Vickers piston pumps have shorter lives because of wear in one heavily loaded thrust ball bearing. Vane pump wear is also higher than desirable. This fluid has no more effect on the synthetic rubber packings in use in aircraft (14) than the present AN-0-366 petroleum hydraulic fluids. The Hydrolube fluids have been reported to cause even less deterioration of natural rubber packings, and this is advantageous in many applications. It is desirable to decrease the rate of wear under conditions of boundary lubrication involving steel on steel, to lower the freezing point below —67 F, and to make it less corrosive to high magnesium alloys. The viscosity at —40 F can be lowered appreciably by increasing the average molecular weight of the polymer additive since the available materials are under 12,000 in molecular weight. An additional decrease could result if more effective wear preventives were found. The resistance of Hydrolube to aircraft fire hazards has been fully confirmed by the Civil Aeronautics Authority flight tests (60), and its utility has been verified in a number of naval planes which have been in operation for two years with excellent results under all extremes of weather, speed and altitude.

Even before completion of this investigation, interest has grown rapidly in applications of these fluids on

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ships, submarines and shore establishments and in a wide variety of industrial applications. One chemical manufacturer is already producing Hydrolube U-4 for Navy aircraft use and a modified fluid is under development by another. For industrial uses fluids are already available having viscosities of 60 and 120 cs. at 100 F, while the freezing points are below —50 F and —15 F respectively. These fluids are being applied in die-casting machinery, manipulators for iron and steel mills (34), hydraulic presses, furnace controls, mining machinery, and hydraulic brakes. High temperature applications are limited, of course, by the boiling point of the aqueous solution.

Conclusions

Despite the variety of fluids studied, the Hydrolube U-4 is the only non-flammable hydraulic fluid available which does not require the installation of different packings. However, the wear prevention is not adequate for some types of pumps. More effective wear preventive additives need to be developed.

Three non-flammable fluids of promise are available which are based on the use of chlorinated hydrocarbons and polymer V.I. improvers, and all require changes in packing materials. The fluid prepared from hexachlorobutadiene appears the most promising; however, information is inadequate on health hazards and on the deterioration of rubber packings under practical conditions of long exposure and extreme temperatures.

The perfluorinated hydrocarbons, ethers, and amines are sufficiently stable and non-flammable, but much long-term organic and physical chemical research remains to be done before suitable hydraulic fluids are likely to be available. Promising directions for synthetic research are evident.

None of the phosphate esters, silicones, and polyglycol ethers of promise for hydraulic applications are resistant to all flammability tests, but for many special applications some compounds have sufficient resistance. The effect on common packings makes the use of phosphate esters least promising. Promising directions have been indicated for the synthesis of improved polyethers, silicones, and phosphorous compounds.

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(*Continued on page* 304)

GREASE SYMPOSIUM

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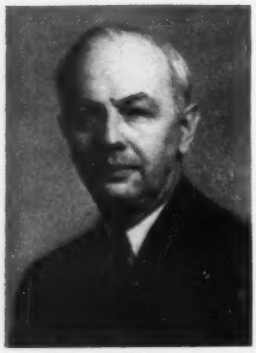
O. L. MAAG

J. H. GUSTAFSON

E. R. HARRIS



L. W. DEUTSCH

C. A. BERG

G. W. MILLER

M. B. LAWTON

FOREWORD

by O. L. Maag, Chief Lubrication Engineer, Timken Roller Bearing Co.

Mr. Maag acted as moderator of the Grease Symposium which was presented at the Fourth Annual Convention of A.S.L.E., New York City, April 11, 1949.

Due to Mr. Maag's long and varied experience in the field of lubrication, we feel that his introductory remarks made at the opening of the Symposium should be brought to the attention of our readers.

"The papers on this program cover the developments made necessary by our continued mechanical progress.

"Formerly, all machines were built with plain bearings, little thought being given to the type of lubricant used or the method of application.

"The authors have all had years of practical experience. They discuss antifriction bearings, which are necessary in this age of high-speed and heavily-loaded bearings; the problems of lubrication encountered; also, the manufacturing improvements required to produce the present-day, high-quality lubricants.

"A group of pioneers in a comparatively new field will enlighten us on methods and new devices for applying lubricants correctly and scientifically to present-day bearing applications. Each author is a specialist through years of experience on the subject he is discussing. The data, therefore, is timely and should command your consideration."

Development of Grease Lubricating Systems

by A. J. Jennings, The Farval Corp.

In the limited time available, I won't be able to give much of the history, or early experiences which led to the development of the modern centralized high pressure systems of lubrication. Perhaps this is just as well, because in the final analysis I am sure your greatest interest will be in an outline of the centralized systems that are available for your use today.

I will therefore attempt to briefly outline the basic principles involved in the several systems and will endeavor to explain how these principles apply to each individual system. In the first place, all centralized systems of grease lubrication employ the piston displacement principle of measurement, whereby one or more pistons reciprocate in a cylinder to discharge a measured amount of grease, at pressures adequate to overcome the bearing resistance. These pistons and cylinders are incorporated in lubricant measuring valves, usually located adjacent to the bearings, and they in turn receive their supply of lubricant from a central pumping unit, located at a convenient point and connected to the measuring valve by hydraulic piping.

Four basic methods are employed for reciprocating the piston in the lubricant measuring valves.

1. One is the so-called single line system whereby these pistons move forward by hydraulic pressure applied to the lubricant in the supply line, and move back under the force of a spring when the pressure is relieved in this main supply line.
2. Another method consists of reversing the flow in a main supply line loop, which causes the pistons to move in one direction when lubricant is pumped through this loop and to move the pistons back again when lubricant is pumped through the supply line loop in the opposite direction.
3. The third method consists of a single line system with lubricant flowing in one direction only and delivering a quantity of lubricant to a measuring valve block, which causes its pistons to recipro-

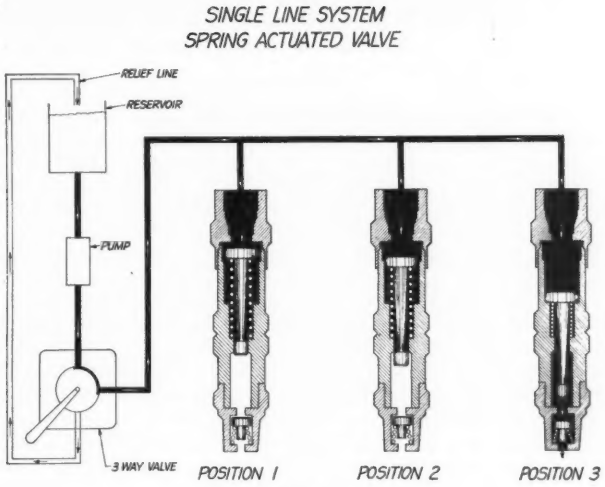


Fig. 1

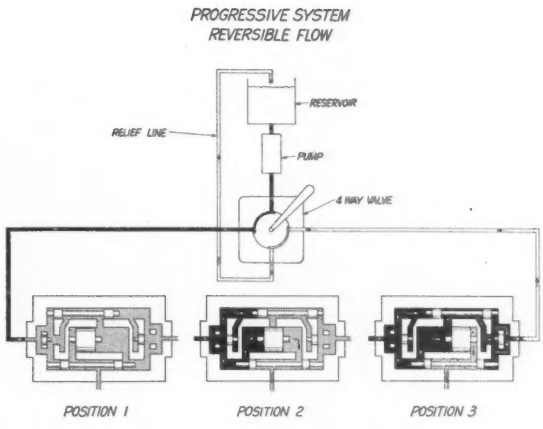


Fig. 3

cate and thus to divide this quantity of lubricant among the several outlets of the valve block.

4. The fourth method employs two parallel supply lines and by alternate application of the pressure to these two lines, the pistons in the measuring valves are moved from one end of their cylinders to the other, discharging measured quantities of lubricant with each operation.

The line drawing in Fig. 1 will illustrate the first method, namely moving the main piston under hydraulic pressure in one direction and returning it by spring action in the opposite direction.

This drawing shows a pump for supplying pressure to the single line, and a two-way valve for relieving the pressure after the measuring valves have operated. When pressure is applied, the main piston is moved forward, as shown in position No. 1, with lubricant by-passing around the head of the piston to completely fill the valve chamber.

In position No. 2, the large head of the piston has moved forward closing the inlet before the smaller head of the piston has opened the outlet.

In position No. 3, the main piston has moved forward to eject a measured quantity of lubricant from the outlet to the bearing. You will note the valve spring has been compressed and will move the main piston back to its normal position upon relief of the pressure in the main supply line.

The valve illustrated on this slide was put on the market in 1926 and it was the heart of the first centralized grease lubricating system to be offered in this country.

Fig. 2 shows one of the lubricant measuring valves that is being offered for grease lubrication by a well known system manufacturer. You will note it employs the method of moving the piston in one direction under hydraulic pressure and in the opposite direction by means of a spring.

In position No. 1 the valve is in its normal at rest position and fully charged with lubricant.

In position No. 2 lubricant pressure at the valve inlet has moved the lower piston upward, permitting the incoming lubricant to flow through the passage at the left and to deliver lubricant to the chamber above the main piston. This causes the main piston to move downward and to discharge the lubricant below it through the valve outlet.

Discharge of lubricant continues until the main piston reaches the end of its downward stroke, as shown in position No. 3. Upon relief of pressure in the supply line, the inlet piston moves downward to establish connection with the vertical passage at the left (as shown in position No. 1), and at the same time the spring moves the main piston upward, transferring the lubricant above it through the vertical passage, and through the drilled holes in the inlet piston, and thus to the spring chamber below the main piston.

Fig. 3 illustrates the loop type of progressive system in which the pistons are reciprocated through reversing the flow of lubricant in the main supply line circuit. Position No. 1 shows the lubricant measuring valve in its normal at rest position, all passages being filled with lubricant.

In position No. 2 the lubricant pressure entering the valve chamber at the left, has moved the small inlet piston and both upper and lower sets of pilot pistons to the right, as shown. Lubricant has entered the main piston chamber through the inlet passage, causing the main piston to move to the right and to discharge lubricant through the passage at the right and to the valve outlet below.

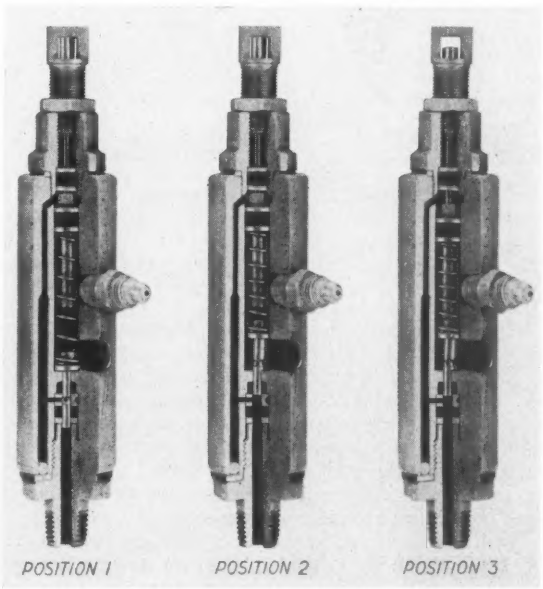


Fig. 2

Delivery of lubricant continues until the main piston has reached the right hand end of the main cylinder, as shown in position No. 3. This movement has uncovered the upper center passage, allowing the grease to flow through the pilot piston chamber and causing the small inlet piston to move to the right and to thus permit the grease to flow to the main supply line leading to the next measuring valve in the circuit.

When the flow in the main supply circuit is reversed, all pistons will be moved to the left (as shown in position No. 1) and movement of the main piston in this direction will also discharge a measured quantity of lubricant through the valve outlet below.

Fig. 4 shows the valve employed in a loop type reversible flow progressive system, as offered by a prominent manufacturer of lubricating systems. In position No. 1, the valve parts are in their normal at rest position and all passages are filled with lubricant.

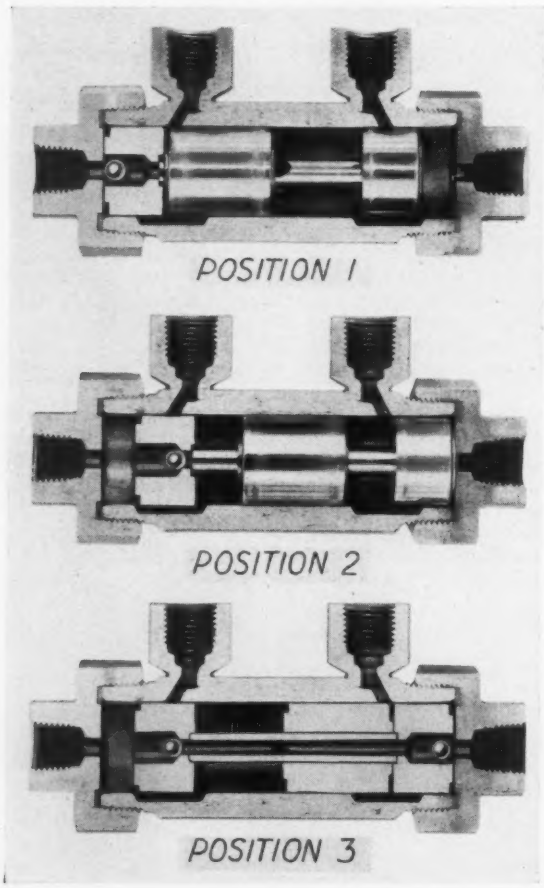


Fig. 4

In position No. 2, lubricant entering the valve chamber from the left has moved the left hand inlet piston to the right and the flow of lubricant has also moved the small ball valve in the center of this inlet piston, to close the port leading to the hollow tube. Lubricant entering the main piston chamber through the undercut passage below the inlet piston has moved the main piston to the right, discharging lubricant through the upper right hand outlet passage leading to a bearing.

Delivery of lubricant continues until the main piston has reached the right hand limit of its travel, as shown in position No. 3. In this position the main piston has uncovered the drilled hole in the hollow valve stem or tube, permitting the lubricant to flow into this tube and through the inlet piston at the right and on to the next lubricant measuring valve.

When the flow is reversed in the main supply circuit, all pistons will be moved to the left (as shown in position No. 1) and this movement of the main piston will discharge a measured quantity of lubricant through the upper left hand valve outlet.

The line drawing in Fig. 5 illustrates the single line non-reversing system and the type of lubricant measuring valve employed to reciprocate the pistons and to divide the lubricant among the six outlets of the valve.

In position No. 1, all passages are filled with lubricant and pressure is being applied from the single supply line through the passages indicated in solid black and the white directional arrows. You will note that the incoming pressure is about to become effective on the right hand end of the lower piston.

In position No. 2, pressure has moved the lower piston to the left, ejecting the lubricant displaced by this movement through the vertical passages indicated by the black arrows to the outlet No. 1. Movement of the lower piston has also ported the supply line passage to the one leading to the right hand end of the center piston, as shown in black and by the white arrows.

In position No. 3 the center piston has been moved to the left by virtue of the pressure developed at its right hand end, and the lubricant displaced by this movement has been ejected from the left hand end through the passages shown, and as indicated by the black directional arrows to the No. 2 outlet. With the center piston moved to the left, the incoming lubricant supply is ported to the passage leading to the right hand end of the upper piston, as shown in black and by the white arrows.

In position No. 4, the upper piston has been moved to the left, by means of the lubricant pressure developed at its right hand end. The lubricant at the left of this piston has been displaced through the passages shown, and as indicated by the black arrows to the No. 3 outlet. After the top piston has moved to the left, the lubricant supply is connected to the passage leading downward to the left hand end of the lower piston, as shown in solid black and by the white directional arrows.

The continuing flow of lubricant from the main supply line will cause each of the three pistons in turn, to be moved to the right, as shown in position No. 1. As each piston moves to the right the lubricant displaced by it will be ejected through a separate outlet and thus the other three outlets will have been served. As long as lubricant flows to this type of valve, the pistons will continue to reverse and deliver lubricant from the valve outlets.

Manually operated single non-reversing units are furnished for centralized grease lubricating systems. Manifolds with 16 or more outlets are common. Similar manifolds of lubricant measuring valves can be added through an additional separate supply line from the pumping unit for each manifold. Additional manifolds may also be connected to an outlet of another manifold to serve those bearings requiring less frequent lubrication.

The line drawing on Fig. 6 illustrates the Dualine System whereby the pistons in the lubricant measuring valves are reciprocated by alternating the flow in each of two main supply lines. This drawing shows a pump for delivering lubricant under pressure, a 4-way valve to direct the lubricant into one of the two supply lines, and at the same time to provide relief of the other line to the reservoir. With the 4-way valve in position No. 1, lubricant is delivered through line No. 2 to the lower inlet of the measuring valve, causing the inlet piston to

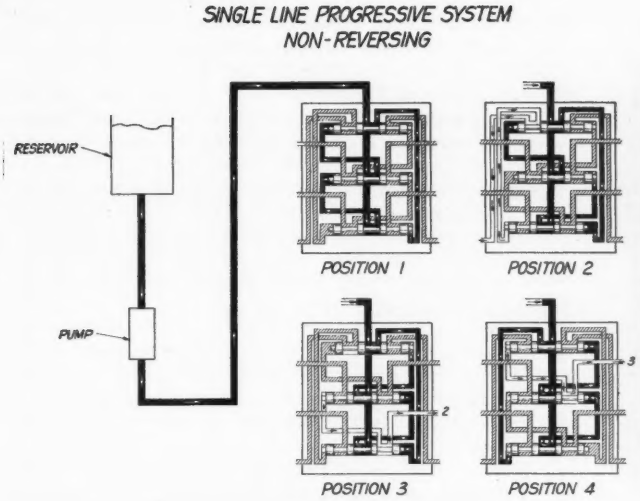


Fig. 5

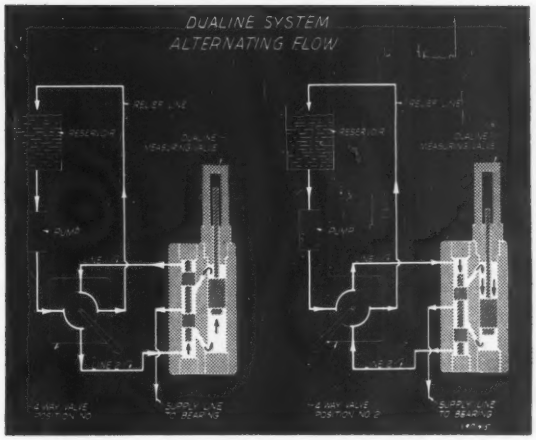


Fig. 6

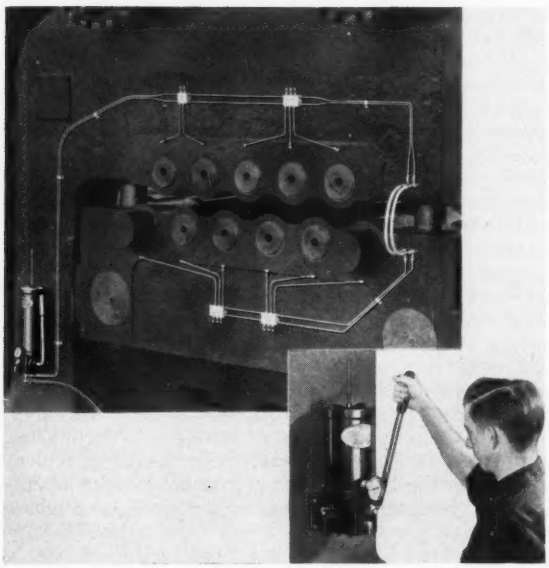


Fig. 7

move upward and admitting lubricant to the lower end of the main chamber, thus moving the piston upward. Lubricant above the main piston is exhausted through the upper passage and out the final outlet to the bearing.

When the 4-way valve is in position No. 2, the lubricant is delivered through line No. 1 to the upper inlet of the measuring valve, causing the inlet piston to move downward and admitting the lubricant to the upper side of the main chamber, thus moving the main piston downward. The lubricant below the main piston is exhausted through the lower passage and out the final outlet to the bearing. Any number of lubricant measuring valves may be connected to the two supply lines to form a complete system.

Fig. 7 shows the Dualine system as made by another leading manufacturer of centralized grease lubricating systems. By alternating the flow of lubricant in the two main supply lines, the pistons in the measuring valves reciprocate to discharge measured quantities of lubricant, as previously described. This figure shows the complete system using a manually operated pumping unit, with a flow directing valve in its base, showing the supply lines connected to the measuring valves, and with the outlets from these valves connected to the bearings.

They represent the essential elements of any of the four systems we have described and all of them will provide complete lubrication of a large number of bearings from one safe, convenient central point in less than one minute. Where operating conditions require the frequent application of lubricant to the bearings, automatic central pumping units are used in place of the manually operated type. The automatic pumping units are available with motor drive and time clock control, or may be mechanically driven from the machines they serve.

Anti-Friction Bearings Pay Dividends on Textile Machinery

by Carl A. Berg, The Fafnir Bearing Co.

Textiles will always be a field of human endeavor. The ingenuity and resourcefulness shown in this industry have brought lasting benefits to man—and always will.

Anti-friction bearings have played a vital part in this field. With the innovation of man-made fibres, the textile industry has become a modern, scientific precision industry. As a consequence, anti-friction bearings have virtually become an essential component in this vast empire of complex machinery.

Not only has the machine designer recognized the advantages of anti-friction bearings but also the textile mills themselves. At first gradually and, of late, much more rapidly they have been replacing their old plain bearings.

This accomplishment which extends over the past three decades reflects the combined effort of the anti-friction bearing and petroleum industries. Running through the records is an unmistakable thread of constant labor, constant search—even at times frustration, but never resignation and finally today the textile industry in the main is cognizant of what we can do in their behalf.

Literally speaking, any machine is only as good as its bearings. Lubricants for the protection of these elements are usually classified in the inventory accounts. Here we find, in the instance of plain bearings, a tendency toward keeping inventory low by obtaining lubricant at the lowest possible cost. The results being the

responsibility for operation, reverting to the Plant Maintenance Department. Machinery worth many thousands of dollars is their problem to protect with a few dollars worth of lubricant.

However, as production demands increased it became fully realized that equipment must operate uninterruptedly. Conversely, during normal spells of tough competition it had also become realized that mills with the best equipment which attains low cost per pound of yarn are the ones which survive.

All of this has brought about the more extensive use of anti-friction bearings in the production of textiles. Correct bearing designs and a positive means of lubrication brought maintenance costs down, saved power, increased machine efficiency and produced better grade textiles. Individually and collectively these are the reasons why progressive mills renovated serviceable machines and specify anti-friction bearings on new equipment.

Precision proved to be an essential in maximum efficiency. This applied distinctly to processing synthetic fibers at first. Today, however, the manufacturer of natural fibers is progressively demanding improved techniques. Anti-friction bearings in no small measure have contributed to both sciences.

By the same token, the petroleum chemist has evolved greases to protect and assure dependable operation of vital ball and roller bearing applications.

Not too many years ago, I believe the early thirty's, ball or roller bearings were given periodic shots of grease and nobody worried much about oxidation until premature bearing failure occurred. It was quite a set-up for the price conscious buyer. He'd purchase the cheapest kind of cup grease and then fight it out with his maintenance engineer and the bearing engineer. The latter usually took it on the chin. Here was the frustration cycle I referred to earlier in this paper.

In practically every instance in which I had personal contact during this trying period, the ball or roller bearing was nearly always considered at fault. And more than once the efficiency of these bearings was debated by the textile mill operators. All of this was most disconcerting to say the least. At times we could have wrung the necks of the oil salesman who sold the cheap grease.

Finally, the grease chemist with his knowledge came to the rescue. With the collaboration of the anti-friction bearing manufacturer, he devised greases which today spell efficient bearing performance.

Not so long ago a Southern mill executive stated to me, "Our aim is to get rid of the oilcans" — and he meant it. His statement was attested by the modification program his mill pursued.

Whereas in the past many of the machinery builders and mills alike associated anti-friction bearings with elevated speeds, today they think and act differently. Why? Because of the simple statement made by the mill man I just mentioned, "We are going to get rid of the oilcan." Grease lubricated ball and roller bearings have been decidedly influential in prompting this trend. Infrequency of lubrication results not only in an enormous saving in the actual cost of the lubricant but effects a great reduction in the cost of oiling labor.

Also, where a machine has to be stopped to oil certain plain bearings, any reduction in the frequency of relubrication adds considerably to the over-all productive efficiency of the machine.

Here it is interesting to note a few months ago in an issue of a textile publication an article entitled "Lubrication System Reduces Machine Stops." The highlight of this treatise indicated that increases in lubricant cost decreased production loss. A tabulation covering the lubrication schedules enumerated numerous locations which called for oil every eight hour shift and an appreciable number calling for oil daily. In contrast, these very applications ball bearing equipped and grease lubricated are adequately maintained with three greasings per year or less.

Contaminated yarn and woven goods have always been a source of grievance with fabricators of textiles. The preponderance of the "second" associated with plain bearing lubrication difficulties has been overcome in no small measure by the use of anti-friction bearings and grease lubrication.

Operational characteristics to be sure dictate the economical lubricant to be utilized in conjunction with anti-friction bearings. Unless otherwise indicated we find grease to be an active exponent in promoting clean, efficient, reliable and economical anti-friction bearing operation.

The supreme test of any textile machine is the service it renders under all conditions of hard and consequent usage. The initial and maintenance costs of a machine must be prorated over the period during which it has given 100% service. A machine which has been built—at a higher cost—with a view to give service will always be found to deliver that service at lowest cost per pound or yard of goods.

Two problems with which we are currently confronted in textile machinery application is, first, friction oxidation (or fretting corrosion) as associated with oscillatory motion, and, second, elevated temperatures in connection with the drying of certain synthetics.

In a measure, the former has been combated through the use of zinc-oxide compound and some of the lithium composition has also assisted to extend useful life.

The latter problem of heat is in some instances of sufficient degree to reduce hardness in standard ball bearing steels. However, anti-friction bearings can be fabricated from material which will withstand the temperatures involved. Nevertheless, a lubrication problem of no mean proportion is presented. Here we question the suitability of silicones. First, due to the current cost of this media and, second, the frequency of replenishment on the basis of twenty-four-hours-a-day operation. To be specific, for instance, an application where 400 F exists, purging and replenishment to avoid evaporation and oxidation, we have been instructed, should take place approximately every eighteen hours. Obviously maintenance cost here would materially offset the simplicity and economics associated with an otherwise practical grease lubricated design.

Both of these lubrication problems appear at this time to be insurmountable with grease as a lubricant, particularly where maximum bearing life is a factor such as in the textile industries. Probably the use of any plastic form of lubricant will never be indicated in these two instances to attain maximum service life.

Here again we enlist the aid of the grease chemists who have done such an outstanding job towards superior ball and roller bearing performance in textile machinery.

The ABC's of Lubricating Grease

by Geo. W. Miller, Battenfeld Grease & Oil Corp.

To the motorist, farmer or industrialist, lubrication is a matter of deep concern. This paper—"The ABC's of Lubricating Grease"—is not directed to you in the audience who are versed in the science of the manufacture and application of this product, but to those who use lubricating grease to keep the wheels of industry moving efficiently.

There is no question as to the versatility or advantage of lubricating grease over straight lubricating oils—when the proper grade or type is chosen and applied. The answer to why more lubricating grease is not used to lubricate our mechanical equipment, we believe, lies, to a great extent, in the answer given by the lubrication engineer of one of our large industrial plants. At a recent A.S.L.E. section meeting, a discussion on lubrication was in progress. The engineer in question asked how he could correct a certain condition he was having difficulty with due to lubrication failure. He was asked, "Why don't you use lubricating grease and eliminate the difficulty?" The lubrication engineer replied, "I am a bit afraid to use grease, perhaps because I know so little about it."

This paper is necessarily short. One cannot cover volumes or an industry in thirty minutes, but we hope to make a start in the dissemination of information you users of lubricants should have to help your understanding of lubricating greases, which are the finest and most efficient lubricants available today.

The consumer very often uses the connotation high temperature grease and high melting point grease or low temperature grease and low melting point grease, synonymously. It is believed that these terms should be clarified and well understood.

The consumer has little interest in this other than an aid to determining the proper type of grease to choose; as very few industrial applications operate close to the melting point of the greases offered for high temperature or low temperature operation.

Your interest lies in being able to recognize the grease by type or kind and what you can expect from the product you choose. To do this, you must have some basic knowledge about the product.

Lubricating greases are produced in many types and forms, some very simple in formulation and some highly technical and complex.

1. Water-resistant type for applications from below zero to approximately 180 F operating temperatures. This classification takes into consideration generally calcium and aluminum base greases.
2. Water-soluble type for applications from average operating temperatures above freezing to temperatures ranging up to 300-400 F and over—generally the soda base greases.
3. Multi-purpose greases — water-resistant types — covering both low and high temperature applications.
4. Greases using synthetic fluids in place of natural mineral oils.

In addition, we will discuss briefly additives, fillers and the value of the more common physical test procedures.

CLASSIFICATION No. 1
(Water-resistant type, generally calcium and aluminum base)

Our first discussion will cover the normal calcium base grease.

Assuming that only quality fats of the proper type and well-refined lubricating oils are used, the selection, then, of a calcium grease is governed by a few fundamentals; namely, the temperature at which the grease is to operate, the type of bearing, the speed of the bearing, the clearance, the pressure, and the frequency of lubrication.

Generally speaking, in selecting calcium greases, we should keep in mind that for very low temperatures a very light viscosity, high viscosity index oil should be used; for average temperatures a medium viscosity oil—perhaps in the SAE 20/30 range; and for higher temperatures and pressures reaching the maximum safety for calcium greases, oils in the SAE 50/70 range or even higher with medium range viscosity index should be used.

The most important factor to keep in mind when selecting a calcium soap grease is that the normal calcium soap greases are generally not safe to use for extended periods of time when operating temperatures will cause rapid evaporation or loss of the water content of the grease. The reason is very simple. Calcium soap greases normally are a mechanical mixture or emulsion of soap, oil and water. Elevated temperatures tend to evaporate the water, which acts as a binder of the soap and oil, allowing the oil to separate readily, and bleed away from the bearing leaving behind a heavy, sticky mass of soap, which soon causes difficulty, especially in anti-friction bearings which normally are not lubricated as often as the sleeve-type bearing.

Aluminum soap greases are very similar to calcium soap greases in their general structure and physical characteristics. The manufacture differs somewhat from calcium soap grease, although the general procedure is the same. Melting points are in about the same range, although aluminum greases can be used at slightly higher temperatures than calcium base greases due to the fact that they are water-free and will not separate due to loss of moisture. They are not quite as good from a low temperature standpoint as calcium greases and are more difficult to handle through pumping equipment at low temperatures, especially temperatures below zero.

Aluminum soap greases do have an advantage over some types of calcium greases due to the fact that there is slightly less tendency for them to bleed oil and, therefore, for lubrication where some oil bleeding or capillary action would be detrimental—as in the lubrication of instruments, some canning equipment, certain textile machinery — aluminum soap types may prove more satisfactory.

CLASSIFICATION No. 2
(Water-soluble type—generally soda base)

This classification covers the normal soda base or what is sometimes known as sponge or fibre grease.

Soda base greases can be used as low temperature greases depending upon the viscosity and V. I. of the oil used, consistency and type fats used to formulate the soap; although when using them as low temperature greases, great care must be taken in their selection. Generally, below freezing and invariably below zero, even with light viscosity oils, soda base greases become very stiff and difficult to pump creating high starting torques and in the case of small anti-friction bearings preventing bearing movement entirely.

Taking into consideration the frequency of lubrication periods, the safe high temperature limit of operation with a soda base grease is very close to its actual melting or dropping point.

Another fact to take into consideration in the selection of a soda base grease is its general structural appearance, whether a short, buttery type or a long, stringy, fibrous type.

Soda base greases are, of course, normally water soluble. However, the solubility of soda base greases can be varied depending on the type of fat used, the viscosity and type of mineral oil, and certain additives can also be used to decrease this solubility. Soda soap grease can be modified to give some degree of water resistance.

Milled or Preworked Grease

Another important factor that must be given consideration in the selection of a grease lubricant, espe-

cially soda soap greases, is the difference between its unworked and worked penetration and is a greater factor in soda base than in calcium or aluminum base greases.

To overcome this undesirable charactertistic, greases of all types and especially soda soap greases can be produced with higher than normal soap contents and then when cool, milled or cold worked to the desired consistency for efficient bearing operation.

This preworking adds hours of life to the lubricant —less frequent greasings are required—better sealing of the bearing is obtained—less tendency to bleed—and a lower shear and torque. The milling operation predigests the grease to fit the bearing's appetite.

CLASSIFICATION No. 3
(Multi-Purpose Greases)

The next classification will be the newer type multi-purpose greases which are being marketed today under various trade names and produced from barium or lithium soaps.

The barium soap grease in general use is of a short fibrous nature in appearance, highly water resistant, with melting point ranging above 400 F. The fact that this grease has very little breakdown under working—the worked and unworked penetration reading about the same—puts it in the class of a multi-purpose grease, as only one consistency is generally required, although various consistencies in this type grease are available for special purposes. Barium greases have good operating characteristics over a wide range of temperatures from well below freezing to 400 F or over.

Lithium soap grease is similar in utility to barium grease but differs in appearance and in some of its general charactertistics. It is smooth and buttery like the calcium greases. Its melting point ranges about 350 F and its low temperature charactertistics are somewhat superior to barium.

At high temperatures more frequent greasing periods are necessary with lithium than barium.

CLASSIFICATION No. 4
(Synthetic Greases)

Perhaps the newest development in lubricating grease is the so-called synthetic grease.

Synthetic greases are produced by the use of normal types of soaps but substituting the synthetic types of hydrocarbons for normal mineral oils.

The greases have great possibilities in both low and high temperature operations and are produced in both water soluble and insoluble types, in many consistency ranges and viscosity ranges of the fluids.

If your problem is one of wide temperature variation, rapid oxidation, gumming, etc., the synthetic product will be of great interest although the cost at present is much higher than normal greases.

The Value of Physical Tests vs. Performance

The question of whether physical and chemical tests are an aid in the proper selection of a grease lubricant is often asked.

Conventional physical and chemical tests are excellent for controlling the uniformity in manufacture—and even for that purpose such controls have their limitations. Two greases with identical physical tests and of the same formulation will give different results when placed in a bearing under identical operating conditions. In addition to physical tests, there must be correlated performance tests that really give the right answers.

Additives for Lubricating Greases

For bearings operating at higher temperatures and heavier loads than normal, oxidation inhibitors and extreme pressure additives are available. Under ordinary conditions oxidation inhibitors would seldom be called in in calcium or aluminum greases unless to protect in shelf storage or for extreme conditions.

For heavier than normal loads, there are many types of extreme pressure additives available and some thought must be given to their proper selection.

Fillers

Fillers are commonly used in many greases for special operating conditions. Such fillers as graphite, carbon black, mica, lead, zinc and other metallic compounds find their way into special formulations to impart what we might term "solid lubrication."

Fillers of the above-mentioned types are desirable where extremely heavy loads and intermittent starting and stopping are encountered—or shock loads such as in steel mill roll bearings, rubber mills, etc.

Application

Proper application is as important as choosing the proper lubricant.

Frequency of lubrication periods is easily charted, if you give due consideration to the many factors involved and already mentioned.

Summary

To summarize, there is no mystery or difficulty connected with the selection of a lubricating grease to lubricate properly the majority of bearings in operation —where a grease-type lubricant can be used to greater satisfaction than a straight oil.

No product, whether it is steel, wood, paint or lubricating grease, will give service beyond the physical properties inherent in that product. If the requirement goes beyond that point — research, development and further engineering are involved and the application becomes a special problem.

In selecting the proper lubricant, do not guess. Have all the facts—type and size of bearing, speed, clearance at normal and at operating temperature, maximum operating pressure in P.S.I., maximum high or low temperature, frequency of lubrication periods, possible contamination by product or atmosphere.

The problem becomes greatly simplified and can be further simplified if sufficient thought is given to lubrication by the design engineer of both equipment and bearings.

Grease Lubrication in Machine Tool Applications

by E. Ralph Harris; Manager Industrial Sales, Alemite Div., Stewart-Warner Corp.

Use of grease on machine tools is an extremely controversial subject. Regardless of specific end use of machines, fundamentally, moving parts of the machine that do the work are lubricated. These parts can be classified into six types of basic mechanisms: Bearings, gears, chains, V-ways and slides, cams and eccentrics, hydraulic systems. All of these are modified by the proportion-relationship and conditions under which they are forced to operate. Having established these fundamentals, a yardstick can now be applied to determine other basic considerations.

Before the development of the petroleum products industry, and we might include the development of the machine tool industry, lubrication was a rather simple process reduced to a decision between the use of water, whale oil or bacon rind.

Sponge Plus Oil Equals Grease—Petroleum development changed this picture. The value of oil as a lubricant is well recognized. Oil is the principal ingredient of practically all lubricating greases. In manufacturing lubricating greases the oils are absorbed into various types of bodies which hold them in a nonfluid condition, the object, of course, being to apply grease to the working surface in a plastic condition so it will remain where it is and not seep out.

One of the greatest contributions in the use of grease has been to create longer machine operation periods because of the lasting qualities of grease lubrication overcoming the frequent shut-down periods required for oil application. Another factor favoring grease usage through longer operating periods is safety.

With today's specialized petroleum products, the following points are worth considering to determine: Type of basic mechanism, method of application best suited, speed of bearing, temperature, load or pressure, water, acid or other specific conditions.

Against this determination, points where grease can be used are considered. Where oil cannot be retained on operating surfaces because of slow action and high pressures; where it is necessary to have lubricant remain on operating surfaces, both during motion and when the machine is idle; where it is necessary to operate bearings having little or no attention for long periods of time; where bearings are subjected to repeated shocks; where there is a probability that oil would drip or splash; where high operating temperatures are encountered; where there is contact with water. Grease also serves to guard against the ingress of foreign materials.

Yardstick for Lubrication—A study of the above considerations will enable us to apply a further yardstick to decide: Where to lubricate, what product to use, how often to lubricate, how lubricant should be applied. These four points represent the biggest problem with which industry is confronted not only in machine tools, but with practically every bearing in America.

In the development of grease usage it is well not to overlook the fact that American ingenuity and the willingness to "try out ideas" has contributed as much if not more than the laboratory scientist or chemist. As a matter of fact, the chemist and the scientist have worked primarily on the job of refining the "good things" developed largely through field effort in the form of "trial and error."

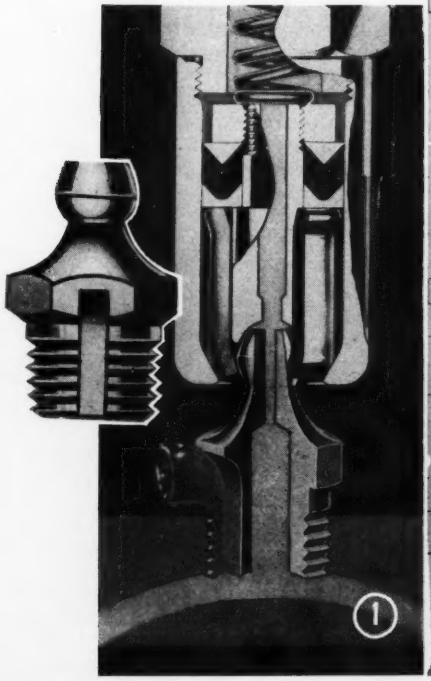
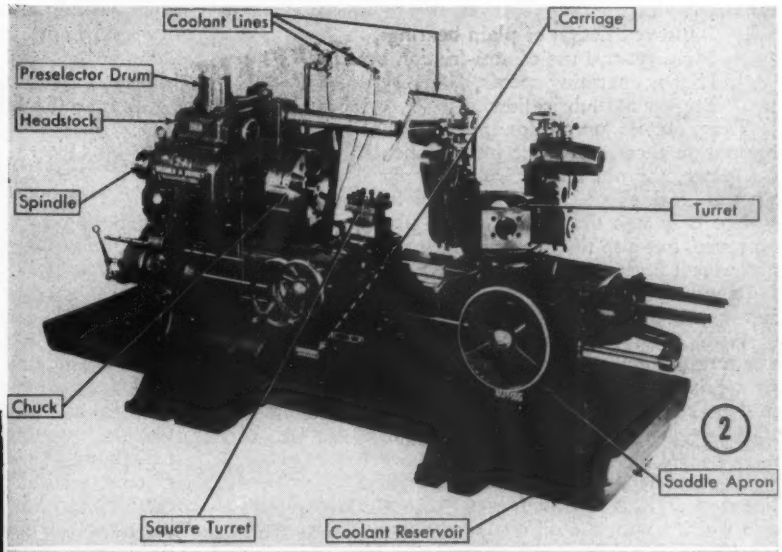
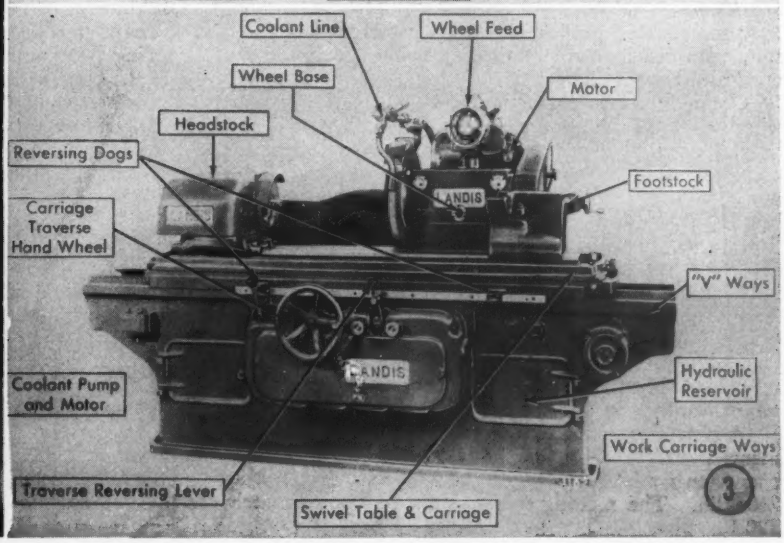


Fig. 1—Fitting developed to prevent excessive lubrication of motor bearings, causing lubricant to be expelled through a slot or port in the fitting so that lubricant backs up when the bearing area is approximately 40 per cent filled.





Figs. 2 and 3—Two of the many machines on which grease lubrication has been employed with good results, at several points.

It is a combination of the two that has brought us from the use of water, the whale and the hog to the present high development in the petroleum industry.

Fig. 1 shows a fitting developed to prevent excessive lubrication of motor bearings, causing lubricant to be expelled through a slot or port in the fitting so that lubricant backs up when the bearing area is approximately 40 per cent filled. Being open to atmosphere also permits any surplus lubricant to be expelled in the event of expansion through heat. Other fittings have been developed to permit excess lubricant to be drained from a bearing in the event of pressure created through either heat or friction.

Figs. 2 and 3 show machines on which grease lubrication has been employed with complete satisfaction. No two cases may be identical. Two machines of the same design may not have exactly the same lubrication requirements.

Use of Grease in the Steel Industry

by L. W. Deutsch, Trabon Engineering Corp.

The use and application of grease in the steel industry has passed through change eras several times in the past 20-25 years. Many factors have contributed to this. A few of the major factors are:

Improved design of plain bearings,
More general use of anti-friction bearings,
Higher operating speeds,
Engineered lubrication.

These factors are so closely related that it is difficult to separate them. As these improvements and changes took place, the old time "Grease Monkey" with his oil can and black oil passed out of the picture.

Not only was the design of the plain type bearing improved, but also the analysis of the metal used. Bearings were carefully machined to close tolerances. The shafts were heat treated and ground. Anti-friction bearings were being used in more and more places.

With these changes came both higher operating speeds and temperatures. Safe operating conditions for the workman were instituted, which meant the plants must be kept clean. Strict operating schedules were set up. Costly shut-downs must be avoided.

How?—Lubrication.

The old brick greases and tallow could not be used. The steel mills trained their own "lubrication engineers" who worked with the oil company engineers to develop greases which would stand up under the new demands. New methods of application were needed and as a result, centralized grease lubrication systems were developed and improved.

Grease lubrication was applied to old mill equipment where oil was formerly used. The grease acted as a seal in old, open plain bearings, holding out water, scale, and other foreign matter. Oil would follow the shaft and the open gears would throw it over a wide area and, in addition, onto the steel. The use of grease eliminated this and bearing life doubled several times over.

The great amount of water in contact with most mill equipment requires that the grease be water repellent. In addition, a grease must be used which will properly lubricate plain bearings, anti-friction bearings and sliding surfaces of all types, all operating under very high loads and extreme shocks. The operating temperature must be taken into account.

A general purpose grease meeting the above requirements would be a lime soap base with E. P. and stickiness agents added. The oil should be 75 S. U. S. at 210 min. The melting point would be approximately 170 F.

Throughout a complete steel plant today, you will probably find Nos. 00, 0, 1 and 2 consistencies used. It is not practical to use a heavy consistency grease on blast furnaces, ore bridges and other outdoor equipment. The No. 00 may be used in gear cases.

For extremely high temperatures, greases have been developed which will stand as high at 400 F. Typical of these is one made under a patented process. This is a lime soap product with an E. P. added. The base oil is 600 sec. at 100 F. The drop point is 400 F.

Another is made using lithium soap and a base mineral oil with a viscosity of 700-750 at 100 F. The minimum drop point is 360 F.

Both the above products are smooth texture and will operate very easily in centralized systems even at low temperatures. The high mechanical stability of these greases after long use makes them very valuable in the steel mills for many applications.

The proper facilities for handling and storing grease are very important. Open barrels should never be left around the mill. The storage buildings should be heated but care should be taken that barrels are not stacked against steam pipes. This may cause separation or the start of mechanical breakdown, or both.

The producers of grease and the lubrication equipment manufacturers are constantly at work developing new and improving old products and methods of application which will benefit not only the steel plants but industry in general.

Engineered lubrication pays large annual dividends.

Grease Application to Mining Machinery

by Morgan B. Lawton, Lincoln Engineering Co.

There are few industries which show financial gains from the use of proper lubricants and modern methods of application more quickly than the mining industry. Most of you are familiar with the adverse conditions under which mining machinery is required to operate and yet, while these conditions cause heavy financial losses in too many mines, they can be overcome.

Month after month, thousands of dollars are squandered in lost production time, parts replacement, maintenance overhead, employee accident and decreased machinery efficiency through faulty lubrication of machinery used in coal mining. These facts have been established by some alert and up-to-date operators who keep careful records on maintenance costs, as well as production costs per ton. They have effected considerable savings in maintenance and production costs by taking two important, although simple, steps:

1. Careful selection and reduction in types of lubricants.
2. Standardizing on modern methods to apply these lubricants.

This paper is dealing with grease application and will not delve into the selection of lubricants, except to point out that in several coal mines today, one grease or oil is successfully being used on jobs where 3 or 4 different types of greases and oils were formerly employed. The results achieved have meant better lubrication, lower prices on quantity purchases, fewer drums, less waste, less guess work for the foreman and oiler and less lubricating equipment.

Astounding progress has been made in coal production methods and equipment in recent years. The lubricating equipment industry has kept step and methods available today are far superior to those used some years ago. For instance, the method of mine-car lubrication used before 1920 consisted of pipe plugs and hand suction guns. Pipe plugs had to be removed from the

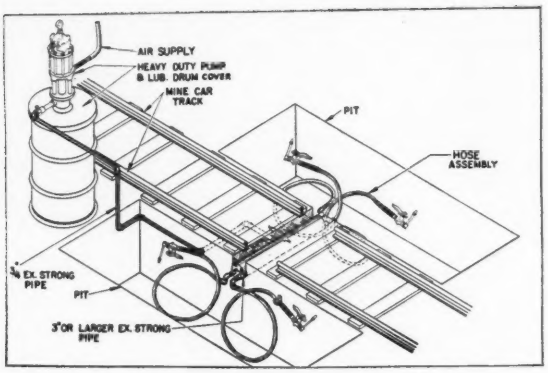


Fig. 1
Proper Installation for Mine Car Lubrication

wheels or axles and the lubricant forced into a reservoir by a suction gun which, due to the suction method of filling, was limited to light, fluid-type greases and resulted in a slow, tedious job plus considerable waste.

An improvement resulted with the introduction of the mine-car "grease plug" and "lock-on" type adapter which permitted replacement of the suction gun by the bucket pump. The plug had a spring actuated ball check that opened to permit entrance of lubricant and remained securely closed against dirt and grit while the mine car was in use.

The need for a better and faster method of lubricating mine-car trucks prompted Lincoln to design and build, in 1923, the first automatic air-operated remotely controlled lubricant pump. This unit had two supply tanks, each holding 500 lbs. of grease. Air pressure was applied on top of the lubricant in each tank to prime the automatic, air-operated, metering pump, which was controlled in operation by manipulating the control, or outlet, valve on the end of the flexible hose.

This method of dispensing lubricant in volume and under pressure permitted lubrication of mine cars by from one to four men simultaneously. It was an important forward step in lubrication, speeding up operation, with consequent saving in man hours, eliminating lubricant waste, and preventing lubricant contamination.

Proper Lubrication of Mine Cars

Fig. 1 shows a modern air-operated pump which dispenses grease from the original refinery container. This heavy duty pump permits lubrication of as many as 400 to 600 mine cars in an eight-hour shift with minimum man-power and no waste of lubricant. This also illustrates the correct layout and proper pipe sizes for setting up a central station for mine-car lubrication. The 3-inch diameter pipe beneath the tracks assures a constant supply of lubricant to all operators on an equal basis.

Automatic-Centralized Lubrication of Machinery

When high-pressure lubrication fittings first came into use on machinery they customarily were mounted at the bearing inlet. It was soon realized, however, that this made it necessary to shut down the machine during lubrication to avoid the risk of injury in attempting to lubricate hard-to-reach bearings. This hazard was eliminated and additional time saved by grouping the fittings in header blocks at accessible locations on the machines and connecting them to the bearings with copper tubing, pipe and flexible hose.

While this method permitted lubrication of machinery in operation, without danger to the oiler, it was more-or-less guesswork as to how much lubricant each bearing received. Some bearings were over-lubricated, others under-lubricated and still others completely overlooked. Thus, in spite of improvements in bearings to compensate for ever-increasing machine speeds, improper application of lubricants still resulted in excessive maintenance costs and loss of production through bearing failures.

This led to the development of the centralized lubricating system which put the right lubricant, in the right quantities, at the right time in all bearings, and from a remote control point. Typical of the mining machinery to which the system is applied is the Myers-Whaley No. 3A Automat coal loader (Fig. 2). It is equipped with a single-line centralized system comprised of 51 adjustable injectors grouped in manifold at locations permitting convenient inspection and adjustment but assuring freedom from damage. Each injector is attached to a bearing by copper tubing or, on moving or rotating shafts, by high-pressure flexible hoses and swivels. The injectors are supplied clean, screened lubricant by a grease pump with a tank capacity of approximately 22 lbs. powered by direct drive off the 123 CD tramming-clutch shaft. This shaft turns up 328 r.p.m. and each bearing is lubricated every three minutes during loader operation.

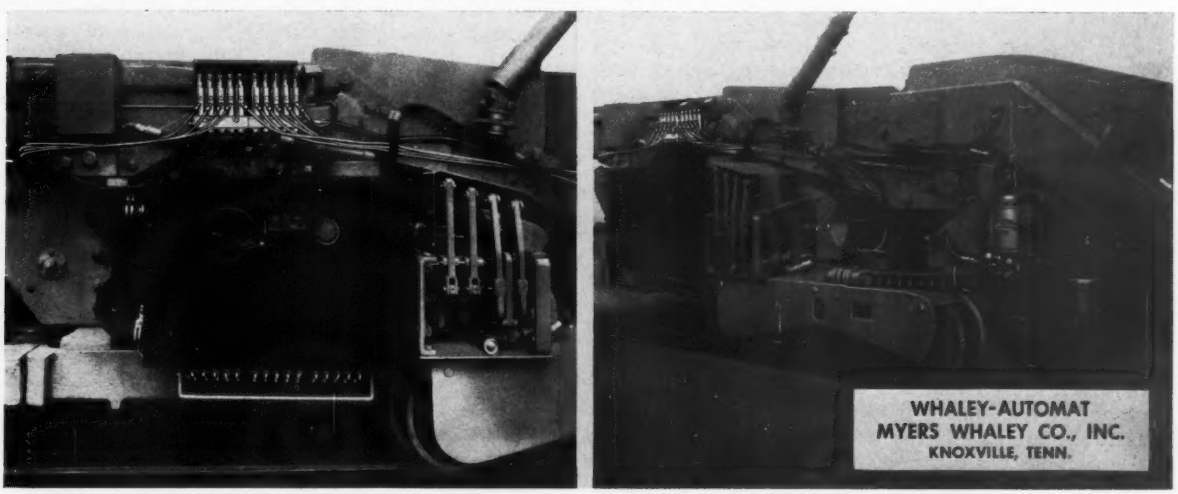


Fig. 2
Application of Single Line Centralized System to Whaley Coal Loader

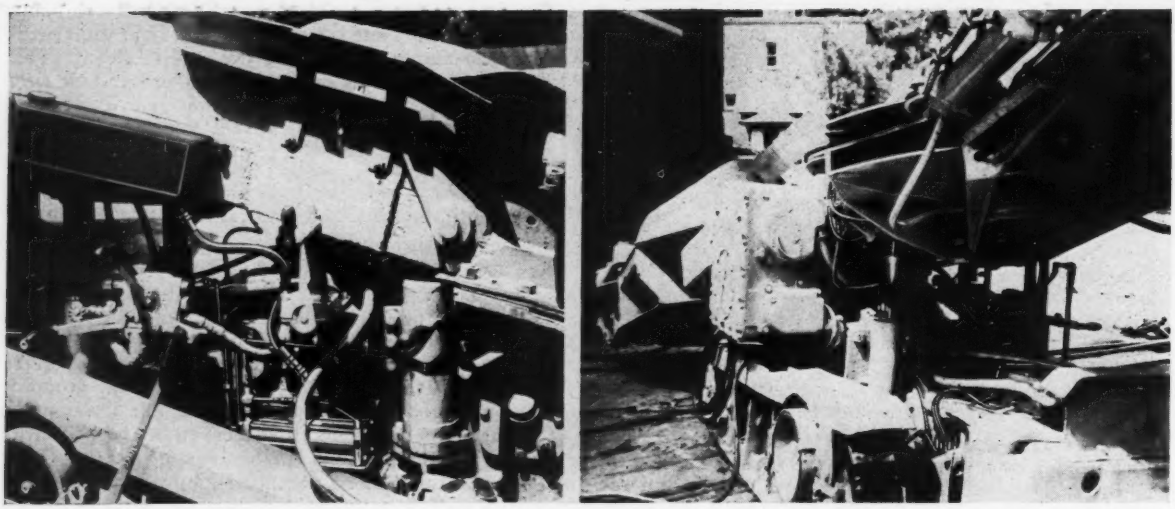


Fig. 3

Single Line Centralized System on Joy Loader

The installation shown was made during overhaul of the loading machine in August, 1944, and is still in operation. No bearing failure has been reported due to faulty lubrication since the original installation was made and no major trouble has been encountered with the system. The loading machine operates three shifts daily, producing approximately 1,350 tons of material. During this time, 15 lbs. of grease are injected through the bearings under high pressure. This quantity could, of course, be very easily reduced by simple external adjustment of the injectors, but the operators prefer to flush the bearings and thereby prevent coal dust, grit and abrasive from entering. They claim that grease is far less expensive than down time and that, furthermore, this consumption represents a considerable saving over the quantity used with former hand methods. A labor saving of two man-hours per loader per shift has also been attained.

So successful was the first installation of a centralized system of automatic lubrication that the owners have since similarly equipped all their loading machines.

Here we see a Joy loader (Fig. 3) equipped with a special type of pump to supply lubricant to the injectors. The pump is hydraulically powered and works in series with the hydraulic system operating the loader. A 3½ to 1 ratio is used and the lubricant-supply tank holds 28 lbs. of grease. Since this system was installed it has resulted in a lubricant saving of approximately 50 percent over the former hand method and has reduced labor cost one man-hour per machine per eight-hour shift. Tabulation of these savings from the first centralized installation resulted in a decision to similarly equip the remaining loaders.

Cleaning Plant Lubrication

A centralized system of lubrication was installed in a cleaning plant or "tipple" which has 457 bearings, 27 of which are on four sets of shakers. The eccentrics, crankshafts and pillow blocks of these shakers are automatically lubricated every five minutes three shifts per day and no bearing replacement or shut down as a result of faulty lubrication has been experienced since the system was installed four years ago, although over 5 million tons of coal passed over the shakers during that time. Prior to the installation, the eccentrics, which drive three-deck shakers, generally were replaced twice a year.

Dispensing of grease from original 400-lb. drums and proper adjustment of the injectors have resulted in a saving of approximately 10 lbs. per shift, or 30 lbs. per day. Additional savings in man-hours have reduced costs by several thousand dollars per year.

The special control panels, mounted on the wall above each pump, are equipped with a time clock that can be set for operation at intervals ranging from 3 to 60 minutes, a pressure switch, a solenoid valve automatically controlling the air supply and an alarm signal giving instant warning if the air supply fails, a lubricant drum is emptied or a supply line breaks.

Shovel Lubrication

Fig. 4 shows a Marion stripping shovel equipped with a single-line centralized lubricating system. This installation has entirely eliminated shutting down the shovel during the lubricating period and assures each bearing of a measured supply of grease at predetermined intervals during operation. With the former hand method, considerable damage was caused to bearings, which were over-lubricated at the beginning of a shift and starved for lubricant when they were finally halted long enough to permit re-application. In addition to saving a large quantity of lubricant per shift, this system has eliminated all danger to the oiler.

Summing up, it can be said that these savings considerably reduce the production cost per ton of coal. Prolonged and economical production with modern mining machinery requires precise application of greases with ease and speed at predetermined intervals. The centralized lubricating system provides the answer on machinery to which it is applicable. Modern, clean methods of handling lubricants from original refinery containers with heavy-duty high-pressure lubricating guns and accessories provide the answer with other types of mining equipment, particularly mine cars. The finest lubricants obtainable depend for their results on the manner in which they are applied. Lubrication practices on mining machinery must be standardized to assure lower operating costs.

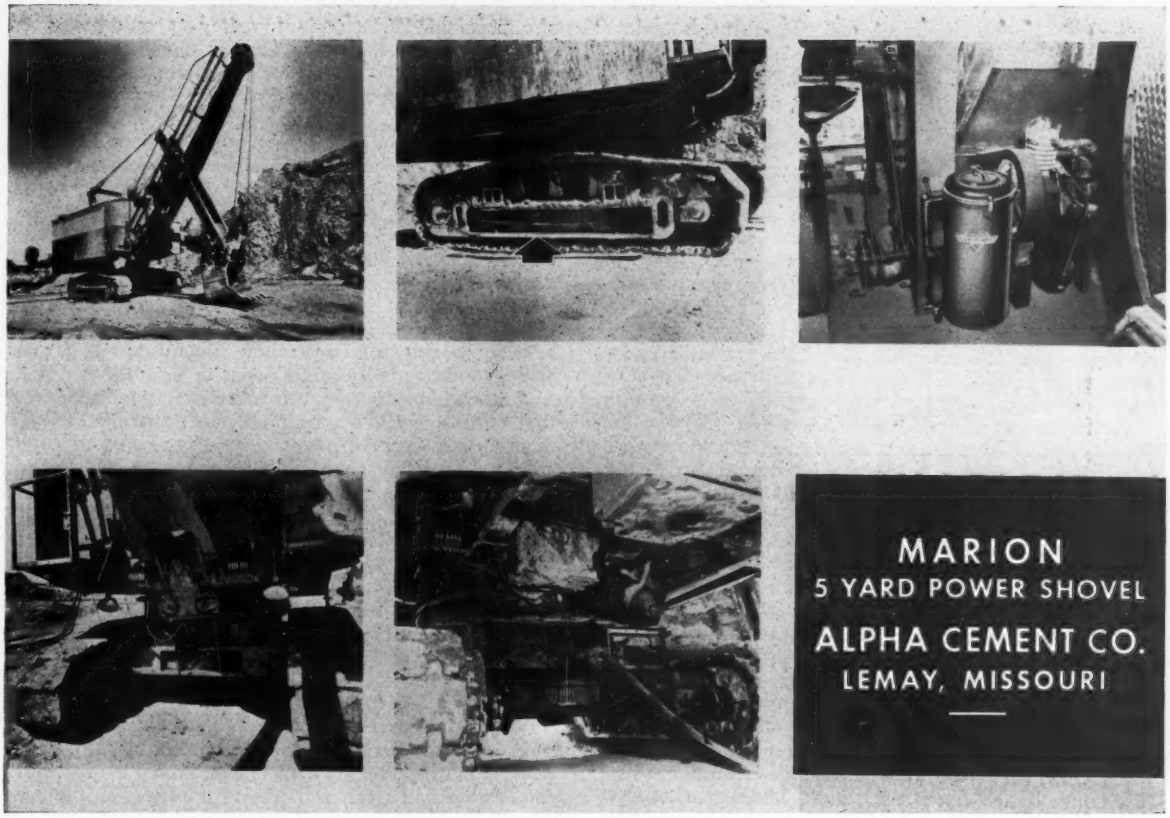


Fig. 4

Stripping Shovel Equipped with Centralized Lubrication

Greases—Their Uses in Anti-Friction Bearings

by J. H. Gustafson, Marlin-Rockwell Corp.

When the first ball bearings were made commercially in England, each bearing was made by hand and such things as interchangeability of bearings was unheard of. It is doubtful if these first manufacturers, whose whole production was used for bicycles, ever dreamed that in a comparatively few years ball bearings would be produced by the thousands every day. Nor is it likely that they could foresee the extreme accuracy with which these same bearings are made. In those early days, limits were held to .001 of an inch on steel balls, while today they are often held as close as 10 millionths of an inch.

One of the most important features in the proper care of anti-friction bearings is lubrication. The efficiency of the bearing is dependent to a large degree on precision of manufacture. However, it only needs one lubrication failure to mar its symmetry, and cause premature bearing failure. Once the surface of the races or rolling elements become roughened, the effects are cumulative due to the rolling action, and bearing failure is inevitable.

Ball and roller bearings are designed to reduce the frictional resistance by means of converting sliding friction to rolling friction. This fact does not mean that proper lubrication is not important. The internal friction in a bearing is caused by a very slight deformation of the rolling elements when under load which in turn causes a small amount of sliding friction rather than absolutely true rolling friction. The retainer or separator is the main source of sliding friction in that it must be supported either by the rolling element or the races with a consequent rubbing when the bearing is rotated. Experience has shown beyond question that proper lubrication is of utmost importance in obtaining the best service from anti-frction bearings. Regardless of how well a bearing may be made, or how carefully it may be installed in the application, the life and service of this bearing will depend on the lubricant used.

In addition to minimizing frictional heat by reducing friction between the sliding elements, a grease for the lubrication of anti-friction bearings should also do the following:

1. The grease should protect the highly finished surfaces with a film of lubricant, thus preventing corrosion by moisture, acid fumes, etc.
2. In may cases the lubricant should form a seal between the shaft and the housing to exclude dirt, moisture, foreign matter, etc.

In special applications such factors as resistance to high temperatures, low temperature torque values and water resistance may be the most important in selecting the proper grease. However, I believe for the lubrication of anti-friction bearings, under normal conditions of load, temperature and speed, the most desirable properties can be summed up as: first, oxidation stability; second, working stability, and third, cleanliness. Oxidation stability is that property of grease which prevents it from deteriorating and forming deposits or corrosion products which can, in some cases, roughen or even lock the bearing. Oxidation stability means stability not only under static conditions such as in storage, but also stability under dynamic conditions.

Most lubricating greases become softer and have a higher penetration number, upon being subjected to working. This working may be in the form of handling

such as filling containers or pumping through grease guns, as well as its being subjected to shear in the lubrication of the bearing. Working stability is the property of greases to maintain, with a minimum change, their original consistency upon being subjected to repeated working. Many of the AN-G grease specifications give requirements for this type of stability. These requirements usually state that the penetration of the grease, after 100,000 strokes in the ASTM Grease Worker, shall be no greater than 375. Those greases which are found to have poor consistency stability are also apt to show excessive aeration and oil separation when in actual use and are not usually recommended for lubrication of double-shielded or double sealed bearings. One can readily see the difficulties that would be encountered in their use in applications such as electric motors or aircraft control bearings.

It has been estimated that more than 90% of all anti-friction bearing failures are due to dirt, either dirt which has found its way into the bearing or dirt in the grease when it is applied. Anti-friction bearings are particularly sensitive to dirt and foreign matter which is more or less abrasive, because of the very high unit pressure between the rolling elements and the races. The rolling motion tends to trap these particles and where unit pressure is high enough, they are actually embedded in the race path. Once the dirt is embedded, the rolling of the ball or roller tends to break away metal particles around the periphery of the crater formed by the particle and bearing failure is imminent. Some feel that blaming bearing failures on foreign matter is merely an alibi of the bearing manufacturers, but the fact remains that this is the most common cause of damage to anti-friction bearings. The type of foreign material will have varying effects on anti-friction bearings. Very fine foreign matter or that which is soft enough to be ground fine by the rolling of the bearing will have a lapping action. The races and balls become worn and the bearing becomes loose and noisy. This lapping action is increased as the fine metal particles are removed from the bearing surfaces thus adding more lapping material.

The question of limits for permissible dirt particles in greases for anti-friction bearings has become more and more important. Today, as never before, anti-friction bearings are being used at higher and higher speeds and under greater and greater loads, making grease cleanliness one of the more important requisites for a good anti-friction bearing lubricant. You all undoubtedly have seen or read the general requirements, that anti-friction bearing greases should not contain dirt, abrasive matter or fillers. This is not sufficient as it sets no limits. To date the only published requirements for number and size of particles permissible is given in the various Army and Navy Aeronautical Grease Specifications. The Services, by means of these specifications, have attempted to set up what they believe are satisfactory maximum dirt counts permissable. I do not believe that these requirements are entirely adequate inasmuch as they allow particles many times larger than the actual clearance present in the bearing. In general, these specifications state that the grease shall not contain dirt or other foreign particles exceeding the following limits:

7500 per cu cm of 25 microns diameter or above
1600 per cu cm of 75 microns diameter or above
0 per cu cm of 125 microns diameter or above

This would mean a grease which contained as many as 7500 per cu cm of 74 microns diameter and 1600 per cu cm of 124 microns diameter would be satisfactory for the lubrication of anti-friction bearings. This would also mean that in 1 cu cm of grease you could have 7500 particles nearly .003 of an inch in diameter and 1600 particles nearly .005 of an inch in diameter. When one considers that it is not unsual to have clearances as little as two-tenths of a thousandth of an inch in anti-friction bearings, you can readily see what particles .003″ to .005″ of an inch in diameter or 15 to 25 times this clearance will do to the operation of these bearings. In the loaded area you do not even have this two-tenths clearance. This is the point where these large particles will either become embedded in the race or ground into a fine lapping compound.

The problem of determining how large and how many dirt particles can be permitted in greases for anti-friction bearings presents many difficulties. As I mentioned, total radial clearance can be as little as .0002″, but in the loaded area this clearance is reduced to 0. Then, theoretically at least, any dirt particle which is larger than a few hundred Angstrom units or larger than a few molecular layers of the soap molecule would be detrimental to the bearing.

It is realized, of course, that it is impossible to obtain this degree of cleanliness, but we do feel that limits should be set on the permissible number and size of dirt particles in greases for anti-friction bearings.

In a recent test program at Marlin-Rockwell, we attempted to determine just how detrimental various types of dirt and foreign matter were to anti-friction bearings. Our tests were run using a 30mm. bore, Conrad bearing operating at 3600 RPM and at 50% of rated load capacity. The effect of varying amounts and sizes of dirt particles was determin d by deliberately contaminating greases with known amounts of dirt and measuring ball wear and pitting produced in the raceway after the test run. Our test results indicated that ball wear was proportioned, not only to the number and size of particles present, but also proportioned to the hardness of the particle. Comparatively soft carbon or graphite particles as small as .04 microns or 16 ten millionths of an inch in diameter were capable of producing ball wear and small pits in the ball path.

Our tests also showed that after a 24-hour run, the pits formed were approximately twice the diameter of the dirt particle itself. In other words, in this 24-hour running period the rolling action of the balls had removed metal particles from the surface around the crater formed by the embedded dirt to the extent that it had doubled in size. At the end of 500 hours, we found that the diameter of the pit had increased to approximately 3 times that of the embedded dirt particles.

Interesting tests were also run using a grease which had been deliberately contaminated with cotton lint. The size of the lint particles averaged .0007″ in diameter and .066″ in length. At the end of our 500-hour test run, we found that these lint particles had actually formed indentations in the ball path. These indentations were relatively shallow, but were from .005″ to .007″ wide, undoubtedly due to the flattening of the cotton fiber when under load. The bearing also had several small spalled areas where apparently the rolling of the balls had removed a quantity of metal from the surface of these indented areas.

In reality the requirements for good anti-friction bearing greases are not too severe. Aside from the special requirements of high temperature resistance, water resistance and low temperature torque which I have already mentioned, we have only

First—good oxidation stability under both static and dynamic conditions,

(*Continued on page* 301)

Mr. R. T. Sanderson received his Bachelor of Science degree from Yale in 1934 and his Ph. D. in Chemistry from the University of Chicago in 1939. His professional experience includes Analytical Chemist, Du Pont; Chief Chemist, Western Geophysical Co. (research on chemical exploration for petroleum); Research Chemist and Project Leader, Beacon Research Laboratories, The Texas Co. (research on aviation gasoline and lubricating oils). In February, 1949, Mr. Sanderson became Associate Professor of Chemistry at University of Florida, Gainesville (research in inorganic chemistry). He has to his credit about twenty publications and patents, including a book "Vacuum Manipulation of Volatile Compounds," John Wiley and Sons, Inc., New York, 1948.

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VISCOSITY - TEMPERATURE - PRESSURE RELATIONSHIPS OF LUBRICATING OILS

One of the most important properties of a lubricating oil is its resistance to flow, or *viscosity*. It is well known that the viscosity of fluids is affected both by temperature and by pressure, decrease in temperature and increase in pressure having the similar result of increasing the viscosity. In lubrication practice where considerable variations in temperature and/or pressure may be encountered, it is useful to be able to predict the behavior of the lubricating fluid under all conditions of operation.

Such prediction is made difficult by the fact that the usual lubricating fluids, such as petroleum oils, are complex mixtures whose properties do not appear to be easily interpreted on the basis of theoretical considerations. Eyring and co-workers *(6)* have developed a theory of viscous flow which is a valuable contribution to the study of fluids, and its application to lubricants has been discussed by Bondi *(1)*. Unfortunately, however, there still seems to be too great a gap between theory and practice, and the practical methods of estimating and representing viscosity dependence on temperature and pressure are of necessity empirical.

The purpose of this paper is to discuss these practical methods.

Viscosity-Temperature

Ever since the relationship between physical properties of lubricating oils and their potential service performance began to be recognized, there has been a need for some simple numerical representation of the dependence of viscosity on temperature.

The problem of devising such a method of representation is much more complicated than might at first appear. The quantitative relationship between viscosity and temperature is far from simple, especially for the complex fluids which are the lubricating oil fractions of petroleum. The rate of change of viscosity with temperature is not a constant, but it also changes continuously with temperature. Furthermore, this rate of change is related to the viscosity of the oil at ordinary temperature. Attempts to formulate precise methematical expressions for this changing rate of change, based on sound fundamental considerations, have been very numerous, but inadequate when applied to the lubricating oil problem. Empirical expressions have been more successful, and that devised by Neil MacCoull *(10)*,

$$\log \log (k.v. + c) = A - B \log T \qquad (1)$$

which is the original basis of the familiar ASTM D341-39 Viscosity-Temperature Chart, has been extremely useful. However, as will be shown presently, none of these until recently has provided the desired dependable representation of viscosity-temperature properties in a simple numerical form.

Viscosity Index

Dean and Davis, twenty years ago *(4, 2, 3)*, avoided some of the complications of this problem in devising the familiar Viscosity Index, which has been very widely used for indicating the dependence of viscosity on temperature for ordinary lubricating oils. This method compares the viscosity-temperature properties of an oil with those of two standard reference oils, one having relatively slight dependence of viscosity on temperature (given the arbitrary value of 100 V.I.) and the other having relatively great dependence of viscosity on temperature (to which V.I. of 0 is assigned). Both reference oils are chosen to have the same viscosity at 210 F as the oil under study.

The success of the V.I. seems to have resulted largely from a fairly wise and fortunate choice of the standard reference oils. The 100 V.I. standards comprised a series of increasingly viscous oils obtained from a highly paraffinic Pennsylvania crude oil, of a type possessing about the least dependence of viscosity on temperature of petroleum oils known at that time. The 0 V.I. reference oils, similarly, were a series of increasingly viscous oils obtained from a highly naphthenic Gulf Coastal crude oil, having relatively great dependence of viscosity on temperature. Thus, as originally devised, the V.I. only represents a comparison of the viscosity-temperature properties of an oil with those of two specific reference oils having the same viscosity at 210 F. There is nothing fundamentally inherent in the V.I. system which justifies the commonly accepted usage of V.I. to compare oils having different viscosities at 210 F, *unless* the following conditions were inherent in the choice of the two reference series:

1) If any progressive changes in viscosity-temperature properties occur with increasing viscosity of oils, then standard series should take this into account.

2) Likewise any progressive changes in the differences between the two standard series must also be taken into account.

Ideally, the value of the V.I. unit should be constant, and therefore independent of both viscosity and V.I., or it should vary progressively and uniformly in accordance with some well-founded relationship.

Until recently, no method of giving the V.I. unit any absolute significance or of knowing whether or not it has a constant or consistent value has been recog-

nized. However, it appears that the standards chosen by Dean and Davis came close enough to fulfilling the conditions stated above to give considerable practical utility to the Viscosity Index. In other words, the V.I. has served widely and rather well as an indication of the relative viscosity-temperature properties of ordinary lubricating oils.

More recently, however, more exacting requirements have led to much justifiable criticism of the V.I. system. It has long been suspected intuitively that the same V.I. value might mean quite different viscosity-temperature properties for oils of different viscosity grades, and it has been demonstrated beyond doubt that when extended above 100 it may lead to entirely irrational results *(8)*. The lack of a clear fundamental basis for the V.I. has encouraged doubt as to its dependability. The arbitrariness of the choice of standard reference oils has helped to raise such questions as the following:

Is the difference between 0 and 100 V.I. equivalent for oils of different viscosity grades? Is the difference between 10 and 20 V.I., for example, equivalent to the difference between 90 and 100, in the same viscosity grade? If changing the molecular structure changes the viscosity at 210 F as well as the V.I., is the V.I. change significant or not?

The answers to these and similar questions depend on more fundamental methods of evaluating these properties.

ASTM Slope

This need for a more fundamental basis of evaluating viscosity-temperature properties has sometimes led to the use of the ASTM Slope, proportional to A in Equation (1) above. The ASTM D341-39 Viscosity-Temperature Chart has rectangular coordinates. The kinematic viscosity scale of the ordinate is based on the expression, log log $(k.v + c)$ where $c = 0.6$ for all viscosities above 1.5 cs but increases slowly with diminishing viscosity to 0.75 at 0.4 cs. The temperature scale of the abscissa is based on log T where T is the absolute temperature in degrees F, *i.e.*, the temperature in degrees Rankine. The viscosity-temperature properties of most oils may be represented quite accurately as a straight line on this chart. Thus only two different viscosity-temperature measurements are needed and any other points may be determined by linear interpolation or extrapolation.

It is a natural mistake to take for granted that the slope of such a line must represent the rate of change of viscosity with temperature; actually it represents the rate of change of the logarithm of the logarithm of the kinematic viscosity plus a constant, with the logarithm of the temperature, which is obviously quite different. It can easily be seen that the slope of a straight line on the ASTM Viscosity-Temperature Chart can have practically no significance as an indication of viscosity-temperature dependence unless it is considered together with the viscosity at a particular temperature. By visual inspection of the ASTM chart it becomes obvious that the same slope must mean different dependence on temperature for oils having different viscosities at a fixed temperature. For, paradoxically, parallel lines on the ASTM chart approach and diverge from each other, when extended. This is of course due to the diminishing logarithmic temperature scale of the chart, such that geometrically parallel lines become closer together in degrees of temperature as they extend toward lower temperatures on the chart. Therefore unless the viscosities are also specified, the ASTM slope can only have uncertain meaning. As an indication of the relative dependence of viscosity on temperature, for oils of different viscosities, it is not applicable.

Relative Viscosity-Temperature Number

In recognition of the need for more fundamental and more satisfactory methods of viscosity-temperature representation, recent work *(11, 12)* has resulted in the development of the "Relative Viscosity-Temperature Number (R.V.T.N.)." This is a single number which compares the actual viscosity versus temperature curve of an oil with that of a hypothetical pure compound having the same viscosity of 210 F and the least dependence of viscosity on temperature believed to be possible for a pure compound of that viscosity.

The Relative Viscosity-Temperature Number was derived in the following way. First, it was observed that for all oils which are linear on the ASTM chart, the curves which are obtained by plotting the kinematic viscosity against the temperature using ordinary rectangular coordinates are very similar. They all show the same general shape, representing a very low rate of change of viscosity with temperature at temperatures corresponding to low viscosities, and showing a gradual increase of the rate of change of viscosity with temperature as the temperature goes down, until a very high rate of change of viscosity with temperature is reached at temperatures corresponding to relatively high viscosities. A typical viscosity-temperature curve is shown in Figure 1. Such curves can only differ appreciably from each other in two ways, extent of curvature and position along the temperature axis. It was found that the extent of curvature, or shape, of one of these curves can be designated by a single number. This number is called

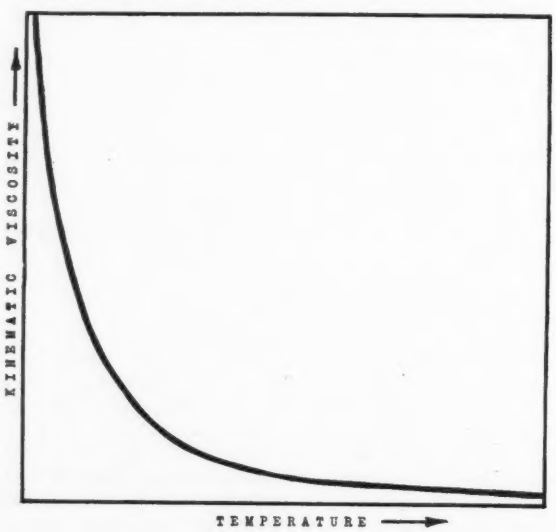

Fig. 1
A Typical Viscosity—Temperature Curve

the "Viscosity-Temperature Number (VTN)" and it is defined merely as equal to the temperature difference between two arbitrarily chosen fixed viscosities; for example:

$$\text{VTN } 5/100 = {}^\circ\text{F (5 cs)} - {}^\circ\text{F (100 cs)} \qquad (2)$$

In other words, all viscosity-temperature curves having the same temperature difference between the same two specified viscosities will be found to have essentially the same extent of curvature, or shape, and they may be caused to coincide merely by shifting them along the temperature axis. That oil whose curve is represented by a higher VTN will have less dependence of viscosity on temperature, as shown by a "flatter" curve.

That the VTN is fundamentally significant is indicated by the facts *(11)* that it is a function of the composition of hydrocarbon mixtures, both binary and polycomponent, and that simple relationships appear to exist between VTN and molecular weight, and VTN and viscosity, of compounds in homologous series. This, of course, is in addition to the fact that the VTN is derived directly from the actual, quantitative dependence of viscosity on temperature, and indeed is directly proportional to the average rate of change of temperature with viscosity, between the chosen viscosity limits.

When the VTN was applied in studies of pure compounds *(11)*, a tendency for the VTN to be larger with greater viscosity was recognized. It was found possible to express this tendency quantitatively for pure compounds in homologous series, as follows:

$$\text{VTN} = \text{A} \log (k.v.\ \text{at}\ t_1) + \text{B} \qquad (3)$$

A and B are constants for a particular homologous series and for a particular temperature t_1.

It is apparent that if the VTN tends to increase with increased viscosity, the VTN alone is therefore inadequate to express completely the viscosity-temperature properties of an oil. If the curves can differ in both VTN (shape) and position along the temperature axis, it is clear that the VTN must be combined in some manner with the viscosity at a specified temperature in order to obtain an adequate expression of *relative* viscosity-temperature properties.

In a search for a basis for taking into account both the shape and the position of the viscosity-temperature curve, the VTN's of all pure compounds in the lubricating oil viscosity range for which data were available were plotted graphically against their viscosities at 210 F. These compounds, numbering nearly 300, included diesters and other types of compounds, as well as hydrocarbons. It was found that the resultant points did not show entirely random distribution, but instead appeared to delineate a smoth, definite, limiting curve. It was further found that this curve could be expressed by the following equation:

$$\text{VTN } 5/100 = 99.2 \log (\text{kin. visc. at } 210\ \text{F}) + 108.8 \qquad (4)$$

It will be recognized that this equation is identical in form with Equation (3) above for a homologous series. Therefore this limiting curve may be regarded as representing a hypothetical homologous series of pure compounds, having the least dependence of viscosity on temperature assumed to be possible for pure compounds at their respective viscosity levels.

The RVTN was then defined as 100 times the ratio of the VTN of an oil to the VTN of a hypothetical standard compound having the same viscosity at a specified temperature:

$$\text{RVTN } 5/100 = \frac{100 \times \text{VTN } 5/100}{\text{VTN } 5/100\ (\text{standard})} \qquad (5)$$

Substituting the expression just derived (Equation 4) for VTN 5/100 (standard)

$$\text{RVTN } 5/100 = \frac{100 \times \text{VTN } 5/100}{99.2 \log (\textit{kin. visc.}\ \text{at } 210\ \text{F}) + 108.8} \qquad (6)$$

The RVTN is thus a single number which takes into account both the shape and the position of the viscosity-temperature curve. As such, it offers considerable promise as a rational replacement for the highly arbitrary Viscosity Index.

A precise determination of the RVTN would involve the following steps:

1) Measurement of kinematic viscosity at two (or more different temperatures (such as 100 and 210 F).
2) Plotting the resulting data on the ASTM D341-39 Viscosity-Temperature Chart.
3) Linear extrapolation or interpolation to determine the temperatures corresponding to 5 and 100 cs, and thus the VTN 5/100.
4) Substitution of the determined values of k.v. 210 F and VTN 5/100 in Equation (6) above and calculation of the RVTN from this equation.

It would be possible, of course, to prepare tables giving the VTN and the RVTN corresponding to all likely values of the kinematic viscosity at 100 and 210 F. However, for practical purposes an approximate value of the RVTN may readily be determined directly from the measured viscosity-temperature data by use of the chart in Figure 2. A straight line extended through the two viscosity points will indicate the corresponding RVTN.

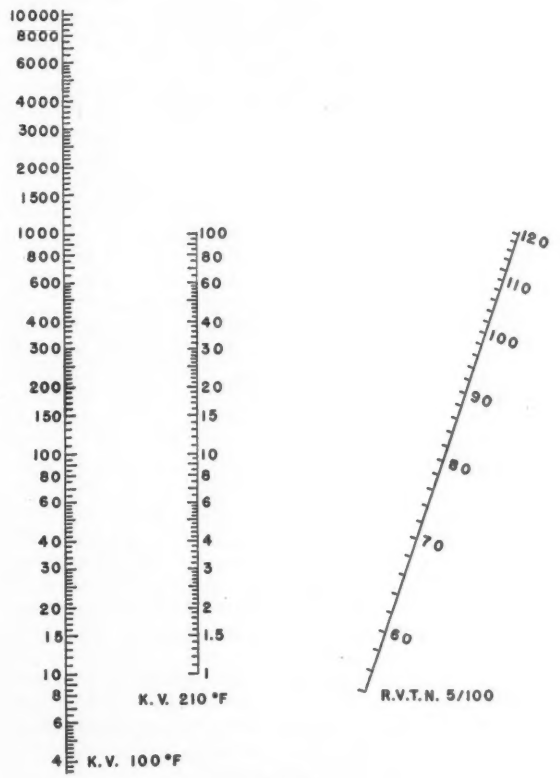

Fig. 2

Viscosity Temperature Chart
"from Industrial and Engineering Chemistry *41*, 377 (1949); reproduced by permission."

The following table gives an idea of the range and magnitude of the RVTN for ordinary oils:

V.I.	*k.v. at 210 F, cs*	*RVTN*
0	2	82
0	6	74
0	14	70
0	25	68
100	2	90
100	6	84
100	14	84
100	25	84

It shows that a V.I. unit, which appears to vary irregularly in value depending on both its numerical value and the viscosity, is roughly about one-tenth of an

RVTN unit. This seems to be a desirable attribute of the RVTN, for a difference of less than 10 in the V.I. scale is regarded usually as insignificant with respect to practical applicability of an oil.

Although an RVTN of 100 is believed to be the highest for a pure compound in the lubricating oil range, higher values have been observed for certain mixtures comprising compounds of widely different molecular weights. Thus polymeric products which have a wide molecular weight distribution, such as olefin oxide polymers and silicones, may have RVTN's above 100. Likewise, oils containing V.I. Improvers, which are high molecular weight materials, may exceed this value. In the light of present knowledge, one would expect values above 100 to represent, not pure compounds or mixtures of molecules of similar size, but mixtures containing components widely different in molecular weights. Toward the other extreme, values below 50 would be quite uncommon. No examples have yet come to the author's attention. In summary, for most lubricating oils and other fluids the RVTN will be found to vary between about 60 and 125, being more commonly between 70 and 100.

It appears that the RVTN represents as close an approach as is now possible to a rational and simple representation of relative viscosity-temperature properties. Its exact form may be subject to refinements, especially when viscosity-temperature data for more pure compounds in the viscosity range above 6 cs at 210 F become available. It seems probable, however, that these properties of fluids in general will be found to be too complicated and too diverse to be represented quantitatively by a single and simple expression.

The RVTN is recommended as a replacement for V.I. but not to be used as a sole criterion of the applicability of an oil to any specific use. The actual measured viscosities at any required temperature limits would be the only completely reliable evidence of viscosity-temperature suitability.

The RVTN has at least three-fold utility as follows:

1) It gives a reasonably reliable estimate of how the viscosity-temperature properties of any oil compare with those of other oils. In particular, it makes possible a comparison of these properties for oils of different viscosity grades. It answers the question: How does the relative position of one oil in its own viscosity class compare with the relative position of another oil in its (different) viscosity class?

2) It provides the most reliable means yet available of determining whether any given treatment of a fluid (such as solvent extraction), when such treatment alters the viscosity, is truly advantageous from the standpoint of viscosity-temperature properties.

3) It serves as a guide for research which is directed toward the improvement of physical properties of fluids through the synthesis of selected structures and composition. Alterations of structure and/or composition usually change the viscosity, and it is then necessary to know whether or not the relative viscosity-temperature properties have thereby been improved.

Viscosity-Temperature-Pressure

It has long been known that the viscosity of liquids increases with the pressure. It is of interest to know how the composition and structure of a fluid may influence the effect of pressure on viscosity. Further, it would be desirable to be able to predict this effect, to obviate the necessity for actual measurements.

Some progress has recently been made in this direction *(13)*. The effect of pressure on the viscosity of some pure hydrocarbons *(7)* was studied. A given amount of compression at constant temperature was found to be exactly equivalent to a given amount of cooling at constant pressure, in effect on the kinematic viscosity, independent of the nature of the hydrocarbon. For example, 10,000 psi compression at 100 F appeared to be equivalent to cooling from 100 F to 58.5 F at one atmosphere pressure. The data for four pure hydrocarbons in the range of 5-50 thousand psi could be expressed as follows:

$$\sqrt{P} = 4718.83 - 1701.54 \log T \qquad (7)$$

where P is the pressure in psi at 100 F equivalent to T in degrees Rankine (°F plus 459.7) at one atmosphere pressure.

From the fact that linear extrapolation of Equation (7) to one atmosphere pressure does not give the correct temperature of 100 F, it is apparent that this equation does not represent the viscosity-temperature-pressure relationship between one atmosphere and 5000 psi. Evidently the initial compression must produce a different effect on the liquid structure from that of further compression.

The above observations permit at least a tentative method of predicting the effect of pressure on viscosity. Since log log (k.v. + 0.6), which is the basis of the ordinate scale of the ASTM Viscosity-Temperature Chart (as pointed out earlier) is, like $\sqrt{P}$, a linear function of log T, then $\sqrt{P}$ can be substituted for log T as the basis of the abscissa scale of the chart. (I.e., log log (k.v. + 0.6) = a—b$\sqrt{P.}$) In other words, a $\sqrt{P}$ scale can be superimposed on the present log T scale of the chart, and the effect of compression at 100 F can be estimated by linear extrapolation of any two viscosity-temperature points. The positions for locating such a pressure scale on the present ASTM chart, which can be calculated from Equation (7), are given as follows:

psi	*°F on ASTM chart*
5,000	79.4
10,000	58.5
15,000	43.0
20,000	30.2
25,000	19.2
30,000	9.6
35,000	0.7
40,000	— 7.1
45,000	—14.5
50,000	—21.3

Many more data are needed to establish the extent of applicability of this method. Viscosity-pressure data published for a few lubricating oils have been found to be in reasonably good agreement with Equation (7). At pressures below 5000 psi they show a uniform divergence from that equation, but the general equivalence between compression at constant temperature and cooling at constant pressure seems to hold. Very many more data are needed before this method can be evaluated adequately, but at present, it appears quite promising *(14)*.

The general observation has been made previously *(9)* that oils having low viscosity-temperature coefficients appear also to have low viscosity-pressure coefficients. To the extent that the above relationships are valid, this observation is quantitatively confirmed. One might reasonably expect, therefore, the effect of structure and composition on the dependence of viscosity on pressure to be similar to the effect on the viscosity-temperature properties. For example, nonpolar linear molecules with little or no branching, and with no cyclic structures except perhaps at one end, would be expected to show less dependence of viscosity on pressure than

A. J. JENNINGS

It is with deep regret that we publish the news of the untimely death of Mr. A. J. Jennings, Vice President in Charge of Sales, the Cleveland Worm and Gear Co. of Cleveland, Ohio, and of its associate company, the Farval Corp. Mr. Jennings passed away following a heart attack, October 30, 1949, at the age of 54. He was born in Adrian, Michigan, and started his business career with E. F. Houghton & Co. of Philadelphia. After 14 years he left Houghton to become Vice President and General Manager of Lubrication Devices, Inc. of Battle Creek, Michigan, the predecessor company to the present Farval Corp. He moved to Cleveland in 1932 when Farval was purchased by the Cleveland Worm and Gear Company. As one of the early and most active figures in the American Society of Lubrication Engineers, Mr. Jennings served on committees and delivered many papers at the National and Section meetings of the Society. He was also active in the American Gear Manufacturers Association, serving at the time of his death as Chairman of the General Commercial Committee. He was a prominent member of the Association of Iron and Steel Engineers; a member of Canterbury Country Club, the Masonic Order, and St. Paul's Episcopal Church of Cleveland. Mr. Jennings is survived by his wife, a daughter, two sons, his mother, and three grandchildren. His loss will be greatly felt by all who knew him.

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would highly cyclized or highly and irregularly branched molecules.

Whether or not similar relations will be found applicable for compression at temperatures other than 100 F remains to be determined but it seems probable that they will. The applicability of the ASTM chart for viscosity-temperature properties at high pressures (in other words, the linearity of isobars) has previously been observed *(5)*. It is obvious that only the accumulation of more experimental data is neded to provide a basis for more general expressions of the quantitative interrelationships of viscosity, temperature, and pressure. An approximate equation of state for liquids in the lubricating oil viscosity range should be derivable, permitting the calculation of any one of the three properties, viscosity, temperature, and pressure, from measured values of the other two.

Future Work

The problem of interrelating quantitatively the effects of temperature, pressure, rate of shear, structure, composition, etc., on the viscosity of fluids is so complex that it seems doubtful whether complete relationships can ever be found which are simultaneously conveniently simple, generally applicable, and quantitatively accurate. There is, however, much practical utility to be derived from approximate expressions such as those discussed above, especially if one is fully cognizant of their limitations. There is much work to be done in determining these limitations and also in developing better methods.

The ASTM equation represents the viscosity-temperature relationships of most liquids of lubricating oil viscosity remarkably well within ordinary temperatures, but deviations from linearity have been observed at both viscosity-temperature extremes. Many more measurements at these extremes should be made, and in the not unlikely event that deviations are found to be the rule rather than the exception, an effort should be made to find a more accurate method of representing viscosity-temperature changes under these conditions.

There is almost unlimited room for research on the effect of chemical composition and structure on viscosity-temperature-pressure relationships. Both pure compounds and synthetic mixtures of known composition should be studied. The expanding use of non-hydrocarbon materials as lubricants, hydraulic fluids, etc., makes it desirable to include such materials in these viscosity studies.

Such studies should help to answer directly some of the problems of immediate practical interest, and also should provide much fundamental information concerning the exact nature of the liquid state. The practical benefits potentially derivable from combining our knowledge of synthetic chemistry with a more complete understanding of fluids would be difficult to over-evaluate.

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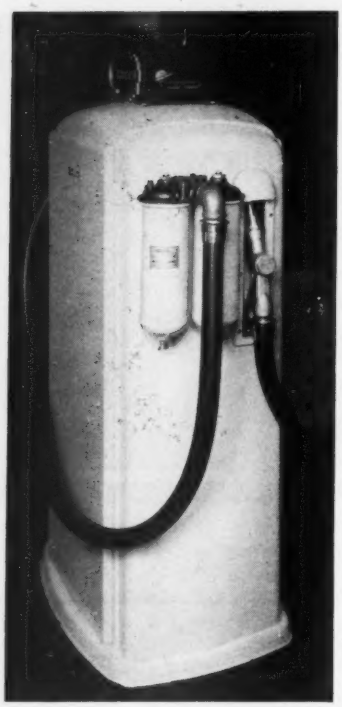
NEW PRODUCTS and EQUIPMENT



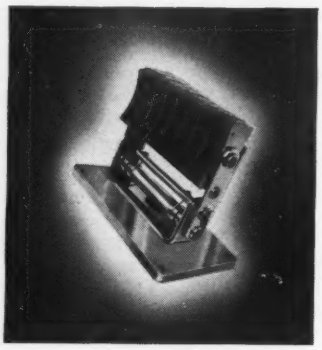
Filters: Commercial Filters Corp., 18 West Third St., Boston 27, Mass.—The new Fulflo Filter recently placed on the market is claimed to be more suitable for attachment to dispensing pumps for fuel or light oils and separates the entrained moisture. Cellulose filtering elements are said to give precision depth filtration and it is stated that under average conditions, the two elements will filter 100,000 gallons, and are quickly renewable at small cost. Flow rate is 15 GPM.

Glass Cylinders: Dunbar Glass Corp., Dunbar, W. Va.—A new catalog lists, among many glass appliances, replacement glass cylinders for oil cups available from 1¼" to 8¾" diameter, and in length up to 18". Catalogs available.

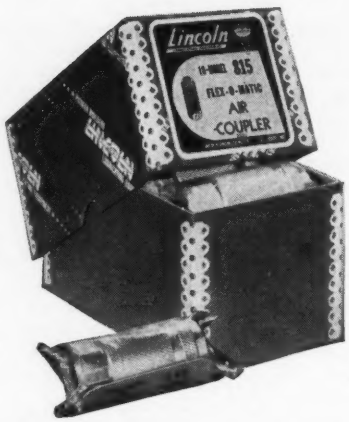
1950 Edition: Carbide and Carbon Chemicals Corp., 30 East 42nd St., New York 17, N. Y.—"Physical Properties of Synthetic Organic Chemicals," a 16-page booklet designed as a condensed guide for users of organic chemicals. The material is presented in tabular form, giving data on applications and physical properties for more than 200 synthetic organic chemicals. Copies available without charge—Form 6136.

Spray Nozzle: Bete Fog Nozzle Co., Greenfield, Mass.—A new line of Spray Nozzles, on which several patents are pending, has a unique spiral design that produces a finer atomization; yet is practically non-clogging, according to the manufacturer. No vanes nor whirl discs are required and it is available in various spray patterns with flow rates from ¼ to 100 GPM.

Journal Lubricator: Miller-Felpax Corp., Department 1, Winona, Minn.—A new lubricator for journals on overhead cranes and similar industrial equipment, consisting of non-glazing felt wicks attached to a holder which keeps the wicks in place with the correct pressure, is claimed to provide full and constant lubrication to bearings and thrust flanges at all times. Models for practically all styles of journal boxes are now available.

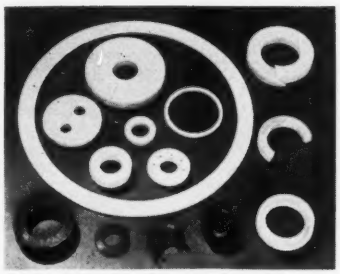


Synthetic Additive: Wynn Friction Proofing Co. of Ohio, Inc., 4117 Perkins Ave., Cleveland 3, Ohio—Good results are claimed by the manufacturer of this product on lubrication problems resulting from temperatures of from minus 60 through 650 F with the unusual properties of granular penetration of the Friction Proofing below the periphery voids. This, to affect lubrication from within the metal itself should external methods of lubrication fail. It is said that complete protection is afforded bearings and bearing areas against all acids such as sea water and industrial acids. Full information available from the manufacturer.



Packaging Program: Lincoln Engineering Company, 5701 Natural Bridge Ave., St. Louis, Mo.—Announcement is made of a new packaging program said to meet the need of manufacturers and distributors for better inventory control, increased protection, and better identification. The sturdy metal edge boxes prevent crushing and are nestible. Quickly identified by standardized color scheme. Sets of the different units are packed in individual, transparent, moisture and dirt proof bags.

Chemical Pump: General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa.—Especially made for many hard to pump chemicals, such as acetone, detergent oils, solvents and so forth. Special diaphragm. Plastic coated. Is said to be resistant to chemicals. Equipped with an adjustable suction pipe, to fit either ¾", 1½" or 2" openings. No. 777 Chemical Pump.

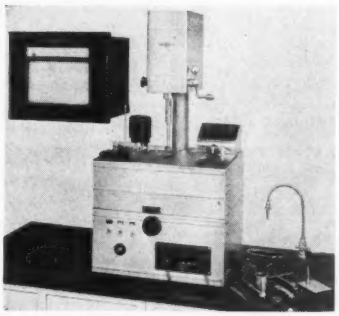


Molded Chemlon: Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill.—Announcement is made of the new molded form of Chemlon, said to retain all of the chemically inert properties of the braided packing. It is claimed by the manufacturer that this new type of packing is not attacked by acids or alkali and stands up for longer periods of time under conditions never before successfully sealed. Chemlon features effective temperatures to 450 F, exceptional electrical properties of the material, and its combination of low power factor and low dielectric constant. Numerous special shapes can be molded for individual requirements.

Rust Preventive: E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.—"A New All-Star Line-Up of Rust Preventives" describes and lists the uses of each of the eleven Rust Veto products. The chart outlines the physical properties and lists information such as thickness and type of film. Free copies available.

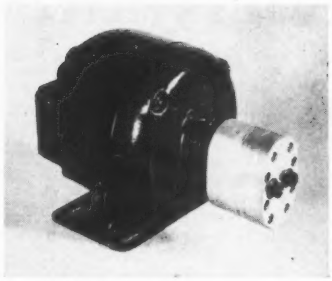
Oil Cup and Gauge: Trico Fuse Mfg. Co., 2948 N. Fifth St., Milwaukee 12, Wisc.—A new development by this company, a combination oil cup and gauge, is claimed to serve a dual purpose—that of visible oil cup and for checking oil levels periodically. Clear plastic top insures visibility. It is said to be corrosion resistant, dust proof, and easy to clean. Available in 1, 2, 4 and 8 oz. capacities. Complete descriptive folder No. 31 available without charge.

Bowser Bulletin: Bowser, Inc., Fort Wayne, Indiana—The modern way to clean, stabilize, dehydrate and degasify lubricating oils is the subject of the new bulletin, describing a new self-contained unit. It is said to prevent formation of acids, gums and resins, and enables oil-sealed vacuum pumps to pull down to 10 microns. Operating principle, case histories, and users' names included in bulletin.



Viscometer: Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.—The new high consistency rotational Viscometer developed in cooperation with The Texas Company is said to measure the viscosity of asphalt and related viscous substances, making possible a complete evaluation of the high consistency materials having complex flow characteristics. Designed primarily for testing roofing, paving and similar products. It has found its use in the testing of viscous paints, varnishes, adhesives and plastics, it is claimed by the manufacturer. Viscometer measures and records viscosity from 0.001 to 1.000 megapoises at various rates of shear. The sample cup can be rotated at any one of ten speeds from 0.0696 to 2200 RPM and these speeds are in direct relation to the rate of shear. The torque, resulting from the viscous drag of the sample on a stator immersed in the sample cup, is recorded by a Brown "ElectroniK" recorder through a Statham strain gauge. To condition the samples, the Viscometer has a constant temperature bath with a range from 20 C to 100 C.

Hydraulic Tubing: Superior Tube Co., 2104 Germantown Ave., Norristown, Pa.—Bulletin 38 gives general and technical information plus specifications on their line of seamless steel hydraulic tubing. Diameters from ⅛" to 1⅛" OD for various operating pressures are stocked.



Hydraulic Pump: Eastern Industries, Inc., 296 Elm St., New Haven 6, Conn.—A newly developed positive pressure oil pump, designed for quick oil changing equipment. Model 1304 is a gear pump, equipped with an aluminum body, bronze gears, cup seal, and attached to a ¼ HP, 1725 RPM, split phase G E motor. Manufacturer claims performance: 1½ GPM at 200 PSI.

Safco No. 770: Swan-Finch Oil Corp., RCA Bldg., West, New York 20, N. Y.—A compound with a consistency of a liquid paste, claimed to combine in a single water-soluble product, all of the essential qualities of a grinding compound and a sulphurized cutting oil. The manufacturer states that when used in grinding operations and mixed with water in ratios as high as 80 to 1, it will prevent wheel-loading, reduce wheel-dressings, and keep work from rusting.

Oakite Booklet: Oakite Products, Inc., 22 Thames St., New York 6, N. Y.—The new Oakite Petroleum Cleaning Booklet lists job tested procedures for handling a wide range of cleaning, degreasing, descaling and related tasks. A variety of uses is quoted and it is thoroughly descriptive of special Oakite materials and methods.

Midwest Office: Commercial Filters Corp., 18 W. Third St., Boston 27, Mass.—The above new sales office, representing the full line of the parent corporation in Boston, was opened at 603 W. Washington Blvd., Chicago, in charge of Mr. Walter H. Magee.

Maintenance Show: Messrs. C. E. Pritchard, L. A. Danse, C. L. Pope, G. L. Sumner, O. L. Maag and E. R. Harris will conduct a Lubrication Panel Wednesday, January 18, 1950, from 9:00 A.M. to 12:30 noon at the Cleveland Auditorium, Cleveland, Ohio, in connection with the Conference and Plant Maintenance Show to be held January 16-19, 1950.

CURRENT LITERATURE

Oil & Gas Journal, Vol. 48, No. 1, May 12, 1949.

STOCKPILING OF LUBRICATING OILS USED
Anon.—p. 56

The National Petroleum Association urged the Armed Services Petroleum Board to institute a program of petroleum stockpiling, starting with lubricating products. A brief outlined the serious situation in which Pennsylvania-grade producers currently find themselves, which resulted in increase in abandonments with a consequent loss of oil reserves. Prices of bright stock and other lube fractions from which lubricants are made have dropped more than 50 per cent. Lubricants could be purchased at a considerable saving to the Government if a stockpiling program were undertaken. The stockpiling of finished products, it was pointed out, was disclosed to be under consideration a year ago.

TWO NEW COAL-TO-OIL PLANTS ARE DEMONSTRATED BY MINES BUREAU
Tuttle, R. B.—pp. 58, 159

Two processing methods for converting coal and lignite to synthetic liquid fuels were demonstrated by Bureau of Mines engineers May 8 at Louisiana, Mo. The two processes operated in combination produce liquid hydrocarbons from heavy fuel oil to jet fuels and aviation gasoline. Aims are to demonstrate the merits of the two methods for converting American coals to oils. The hydrogenation unit, first of the plants to be placed in operation, is based on the Bergius-I. G. Farben process. Design of the gas-synthesis unit is a modification of the Fischer-Tropsch process.

PRODUCTION OF CHEMICALS BY OXIDATION OF NATURAL-GAS HYDROCARBONS
Wirges, M. F., and Palm, J. W.—pp. 90, 92, 114

Production of chemicals by direct oxidation of natural gas has been of increasing industrial interest since installation of the pioneer plant by Cities Service Oil Company at Tallant, Oklahoma, in 1928. After installation of the Tallant plant, other plants were constructed by Cities Service near Oklahoma City and Seminole, Oklahoma. Direct oxidation of hydrocarbons has recently been employed by Celanese Corporation, near Bishop, Texas, and by McCarthy Chemical Company in its plant near Winnie, Texas. Considerable data have been published concerning this reaction and flowsheets of the processes in use have been published. The purposes of this paper are to give a general discussion of methods of carrying out the oxidation reaction and to summarize the data concerning the effect of the important variables on the reaction. The authors are with Cities Service Oil Company at Tallant, Oklahoma. The article is a portion of a paper presented at the regional meeting of American Institute of Chemical Engineers, Tulsa, May 8-11.

Vol. 48, No. 3, May 26, 1949

SHELL OIL COMPLETES $50,000,000 PETROCHEMICAL PLANT EXPANSION
McCaslin, L. S., Jr.—pp. 64-67, 108-110

The chemical plant is located 20 miles outside of Houston at Deer Park, adjacent to Shell Oil Co., Inc.'s 115,000-bbl. refinery. Refinery products which in the past have been considered waste but now have alternatively valuable uses are the basic ingredients of the 19 major products produced by the chemical plant. (See accompanying table.) First step by Shell Chemical in the construction of a chemical plant in Houston area was taken in December, 1940. In June, 1945, an allyl alcohol plant was completed. Two more chemical products were added to the Shell's output in 1946 with the completion of plants to produce epichlorohydrin and glycerol dichlorohydrin. The year of 1948 highlighted the $50,000,000 expansion program. Plants were completed during the year for producing secondary butyl alcohol and methyl ethyl ketone, glycerin, ethyl alcohol, ethyl chloride and hexylene glycol. The company-developed process made possible the world's first synthetic glycerin plant. On pp. 108-9 principal products of Shell Chemical Corp. are listed with their uses.

SLAUGHTER GASOLINE PLANT. OUTSTANDING EXAMPLE OF COOPERATION IN WHICH EIGHT COMPANIES UNITE IN ORDER TO OBTAIN THE MAXIMUM UTILIZATION OF NATURAL GAS
Bellah, J. S., Mertz, R. U., and Kilmer, J. W.—pp. 68-70, 73, 110-111

Eight companies are joint owners of this venture. They are Stanolind Oil & Gas Co., The Texas Co., Honolulu Oil Corp., Magnolia Petroleum Co., Devonian Oil Co., Atlantic Refining Co., Saltmount Oil Co. and Mid-Continent Petroleum Corp. Although Stanolind is the largest owner in the plant, and is the operator, its participation is only a little more than 25 per cent. The article discusses field-gas gathering system and compressors, hydrogen sulfide removal system, absorption and distillation system, residue gas dehydrogenation, liquid product treating, fractionation system, storage and loading, utilities, etc.

ESTIMATING OCTANE NUMBERS OF THERMAL GASOLINE
Nelson, W. L.—p. 93

A 13.8° A.P.I. gravity crude oil is probably an asphalt or naphthene-base oil, and the octane number of the gasoline produced by thermal cracking will be relatively high in octane number. Likewise, if the crude oil contains any straight-run gasoline, it too will have a high octane number. Generalities are dangerous because the behavior of stocks varies widely.

NEW PACKAGE AND GREASE PLANT OPENED ON WEST COAST
Anon.—pp. 95-96

Standard Oil Co. of California has placed in operation at its Richmond refinery a new package and grease plant for manufacture of more than 250 miscellaneous petroleum products. The new installation is highly automatic.

COMBINATION LUBE-OIL PLANT. SHELL OIL INSTALLS PROPANE-DEASPHALTING AND PHENOL-EXTRACTION UNITS AT HOUSTON
Anon.—pp. 98, 101

Two of the latest Shell Oil Co., Inc., Houston refinery lubricating-oil units to go into operation—a propane-deasphalting unit and a phenol-extraction unit—are designed and constructed as one combination unit with common facilities and control. The propane-deasphalting unit processes 4,500 bbl. per day of reduced crude, the residue of a vacuum distillation operation. Production from this unit becomes part of the feed to the 5,800-bbl. daily phenol-extraction unit, along with fractions from other refinery operations at Shell's plant.

SINCLAIR COMPLETES WORK ON REFINERY EXPANSION
Anon.—p. 129

Sinclair Oil Corp. has completed its postwar program of expansion and modernization involving refinery additions and centralization, major additions to products pipe lines, modernization of marketing facilities, and a new research and development laboratory at Harvey, Ill. Capital expenditures of the company this year will be considerably below the $100,000,000 outlay of 1948. Gasoline sales of the company the first four months of this year were up 8.17 per cent, but estimated consolidated earnings the first quarter of 1949 dropped to about $15,000,000 from $21,000,000 in the same period last year.

SINCLAIR PETROLEUM SPUDS FIRST WELL EVER DRILLED IN ETHIOPIA
Anon.—p. 157

The first oil well ever drilled in Ethiopia was spudded on May 17 by Sinclair Petroleum Co. at a location in the Gumburo Hills district of the Province of Ogaden.

PLANS FOR NEW DOMINICAN REFINERY BEING COMPLETED
Anon.—p. 157

Location, size and type of a proposed $15,000,000 refinery to be erected in the Dominican Republic were being discussed in Ciudad Trujillo between government officials and representatives of International Industrial Consultants, S.A., which has the contract for construction of the refinery. The refinery, as originally proposed, would be a 25,000-bbl. unit to operate on imported crude.

Oil, Paint and Drug Reporter, Vol. 155, No. 21, May 23, 1949

SYNTHETIC ORGANIC CHEMICALS CENSUS FOR 1947 PUBLISHED
Anon.—p. 4

The United States Tariff Commission has issued its printed report for 1947 on production and sales of synthetic organic chemicals. It shows that sales of these materials, including crudes, had a total value of $2,500,000,000 in that year, comprising 26,400,000,000 pounds of various materials. Total production was 38,000,000,000 pounds, the difference being largely in material consumed in conversion operations in producers' plants. Slightly more than 1,000,000,000 gallons of tars (coal, watergas, and oilgas) were recovered from all sources in 1947. Some data for 1947 were as follows:

Benzene (other than motor): production, 167,600,000 gal.; increase, 23.0%. Toluene (including petroleum derivative): production, 60,700,000 gal.; increase, 79.6%. Napthalene: production, 314,700,000 lbs.; increase, 29.9%. Creosote oil: production, 158,500,000 gal.; increase. 16.9%.

Petroleum Processing, Vol. 4, No. 5, May, 1949

A MASS SPECTROMETER. A TOOL FOR THE PETROLEUM PROCESSOR
Kinder, J. F., and Wertzler, R.—pp. 515-518

The mass spectrometer is capable of rapid and accurate analysis of many refinery streams and other mixtures encountered in petroleum processing and research. Types of materials which have been analyzed by one refinery include streams of C_1 through C_5, pilot plant samples through C_7, miscellaneous aro-

matics, flue gases, compounds containing sulfur, and others. Methods of handling samples, the instrument, maintenance, and calculations which have been proved satisfactory by three years of experience are described.

AIRCRAFT FUEL TEST METHOD MORE RAPID THROUGH USE OF AUTOMATIC CONTROLLERS
Anon.—pp. 573-574

Engine testing of aircraft fuels under supercharged conditions with more precise control of test variables and considerable reduction in time has been accomplished by two automatic controller arrangements devised by engineers of the Beacon, N. Y., research laboratories of The Texas Co. The equipment used is described.

PATENTS REVEAL NEW METHODS USED TO IMPROVE OXIDATION RESISTANCE PROPERTIES OF LUBE OILS
Gaylor, P. J.—pp. 577-578

Resistance to oxidation has become an important requirement for lubricating oils employed in internal combustion engines or in turbines. The case is particularly so with turbine oils, which are generally used for years before they are replaced. The author reviews the methods aiming at increasing the oxidation resistance of oils, as revealed in recent patent literature. The combination of contract decoloration and fractional distillation in one continuous process and other innovations in treating lubricating and turbine oils are covered.

MAGNETIC FLOWMETER
Uhl, W. C.—p. 585

The "Magna-Sight" magnetic flowmeter is described briefly. The instrument is equally useful for clear and opaque streams.

CORROSION PROTECTION
Uhl, W. C.—p. 586

Cathodic protection against corrosion in heat exchangers, piping, and similar equipment can be obtained by use of the new "Cor-In" Corrosion Inhibitor Zinc Rods, which are fitted with standard pipe-plug ends and can be screwed directly into the equipment needing protection.

CONGRESS SHOULD RE-APPRAISE THE SYNTHETIC FUELS PROGRAM
Editorial—p. 616

The editorial comments on the statements of C. F. Smith, at the API Refining Division meeting in Houston, that residual oils, now burdensome to refiners, are a more economic source of light liquid fuels than coal and shale.

Petroleum Times, Vol. 53, No. 1350, May 6, 1949

METAL CORROSION PREVENTION BY SHELL V. P. I.
Anon.—p. 304

Shell V.P.I. is a powerful corrosion inhibitor developed by the Shell Petroleum Company for preventing corrosion of iron and steel and other metals between manufacturing steps, in packages for shipment and during storage. It is a synthetic chemical with unique properties that make possible an entirely new method of corrosion-preventive packaging. It is a white crystalline stable organic compound which very slowly sublimes or vaporizes. The vapor—which is odorless, non-toxic and non-injurious to the skin—completely surrounds any article in an enclosed space and prevents corrosion by moisture and air. Direct contact of solid V.P.I. with the metal is not required. V.P.I. acts by forming an invisible, thin, protective film on the surface of the metal and this film is maintained as long as V.P.I. is present in the atmosphere surrounding it.

Revue De L'Institut Francais Du Petrole et Annales Des Combustibles Liquides, Vol. 4, No. 3, March, 1949

MANUFACTURE AND USE OF SOLUBLE OILS AND GREASES
Plassat, H.—pp. 80-94

The required properties of the ordinary types of soluble oils for metal working are reviewed as well as those of emulsions resulting from the dilution of these oils in water. The generally accepted theoretical data on the formation and stability of emulsions are indicated. A table shows the most usual basic constituents. New surface-active agents now offered by the chemical industry can be used in the preparation of soluble oils. The use of the main types of soluble oils and greases is discussed.

CONSTRUCTION OF SOME APPARATUS FOR STUDYING POROSITY
Houpeurt, A.—pp. 95-102

In accordance with its research program for 1948, the Production Laboratory of the French Petroleum Institute (Institut Francais de Petrole) has built a field porosimeter which is described. Other devices have been built on the same principle. The theory of these apparatus is taken up.

RELATIONS BETWEEN REFRACTION, DENSITY AND STRUCTURE OF A SERIES OF HOMOLOGOUS HYDROCARBONS
Smittenberg, G., and Mulder, D.—pp. D-36, D-38
(Rec. Trav. Chim. Pays-Bas., Vol. 67, Nov., 1948, pp. 813-838)

It was found that relations between the physical constants (density, refraction and structure) of the hydrocarbons belonging to a homologous series can be expressed by means of an empirical formula which is presented.

The Technical Survey, Vol. 5, No. 14, April 2, 1949

DIESEL ENGINE FED WITH A FUEL OIL-COAL MIXTURE
Anon.—p. 215
(N. Y. Herald Trib., March 24, 1949, p. 1)

Rice of N. C. St. Coll. has been operating a diesel engine fed with a fuel oil-coal mixture (about 55-45). An emulsion-like mixture, about as thick as milk of magnesia, is being used to run the engine for a long period. Although the mixture does not clog the cylinders, it does tend to foul up the fuel system. Tests are now in progress in effect on engine wear.

ALUMINUM SOAP — HYDROCARBON SYSTEMS
Smith, et al—p. 215
(J. Amer. Oil, Chem. Soc., March, 1949, p. 135)

Study of aluminum soap-hydrocarbon systems—effect of additives and metathesis.

Vol. 5, No. 15, April 9, 1949

SULFUR FROM ACID SLUDGE
Anon.—p. 227
(J. Commerce, April 1, 1949, p. 3)

Southern Acid & Sulphur Company is designing a commercial plant for handling 110 tons of refinery acid sludge per day. Herndon described a method for obtaining high quality (99.97%) sulfur by processing refinery gas and natural gas residues containing hydrogen sulfide.

TRIMETHYLHEXANOL
Anon.—p. 227
(J. Commerce, April 1, 1949, p. 3)

Bruner of duPont announced trimethylhexanol, a new long chain alcohol which offers promise for synthetic lubricants, additives and plasticizers. It is now available for commercial use.

NEW PROCESS FOR REMOVING SULFUR
Anon.—p. 231-232
(J. Commerce, April 1, 1949, p. 3)

Voorhies of Esso Laboratories reports that more high test gasoline from poor grades of crude oil can be made by a new process for removing sulfur. Addition of hydrogen under relatively low pressure to petroleum prior to cracking eliminates most of the sulfur and the entire change from low grade crude to high grade gasoline can be accomplished in a single step.

VISCOMETER
Thompson—p. 232
(J. Sci. Insts. March, 1949, pp. 75-6)

Falling sphere viscometer for use with opaque liquids.

PEROXIDE CATALYSTS
Rybolt, et al—p. 236
(Mod. Plast. April, 1949, p. 101)

Organic peroxide catalysts for polyesters.

Vol. 5, No. 16, April 16, 1949

HIGH TEMPERATURE LUBRICATION
Ross—p. 247
(Ceram. Ind., April, 1949, p. 83

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NEWS OF THE SECTIONS

NEW SECTION

On Thursday evening, October 6th, a group of interested men met at the Hotel McCurdy in Evansville, Indiana, with National Secretary W. F. Leonard. After a brief talk on the aims and accomplishments of the Society, an expression of opinion was called for and it was unanimously voted by those present to establish an Evansville Section of the A.S.L.E. Proceeding with the formal election, Mr. R. C. Garretson of International Harvester Co. was elected Chairman and Mr. W. C. Kerney of Shell Oil Co. was elected Secretary-Treasurer. We are very glad indeed to welcome Evansville into the growing ranks of our Sections. The first technical session will be held in the latter part of November.

DAYTON

Mr. R. F. McKibben, Lubrication Engineer for the National Cash Register Co., and a Director of A.S.L.E., opened the fall season with his talk on "Control of Industrial Hydraulic Fluids." Mr. H. L. Sellers, Secretary of this Section, presents the following highlights on the subject:

"In introducing this subject, Mr. McKibben pointed out the need for controls:

1. To protect investment in equipment costing from $2,500 to $25,000.
2. To protect against loss in production.
3. To lower production cost through decreased maintenance.

The methods used to establish controls were:

1. A card system showing make of machine and oil change periods.
2. Analysis of samples taken from these machines once each month.

With this data, case histories were developed indicating that it would be necessary to divide the equipment into two classifications. The first is the type of machine which showed a high percentage of outside contaminants due to water on cutting oils leaking back into the hydraulic system. These units were set up for change every three months and the proper viscosity straight mineral oil is used as a hydraulic medium. However, in cases where the machines indicated the absence of outside contaminants, they have been operating these units with a rust and oxidation inhibited hydraulic oil. Their records prove that with this type of oil, maintenance costs have been lowered. The oil in these machines is analyzed every six months and changed only when the viscosity varies to a plus 10% or the neutralization number exceeds .25. A discussion on this subject by Mr. V. C. Hutton, Lubrication Engineer for Delco Products, Division of General Motors, outlined General Motors standards for evaluating hydraulic oils."

ALL SECTIONS—ATTENTION
"Every Member Get a Member"

Mr. E. M. May, Chairman National Membership Committee of A.S.L.E., has devised a membership contest. All Section Chairmen have been advised that beginning October 1, 1949 and terminating March 31, 1950, a membership contest between the various Sections is in effect. The Section showing the greatest percentage of increase will be presented with a suitable award at the annual meeting in Detroit. We are attempting to double our membership from what it was at the time of the New York meeting in April, 1949. If every member will get a member, that expectation will be realized. The teams are:

Baltimore vs. Philadelphia
Chicago vs. Dayton
Cleveland-Youngstown vs. Buffalo
Boston vs. Connecticut
Pittsburgh vs. Fort Wayne
Detroit vs. Milwaukee
Los Angeles vs. Northern California
Indianapolis vs. St. Louis
New York vs. Twin Cities

DETROIT

Members of this Section were hosts to their wives at the regular monthly meeting in September, for the express purpose of acquainting the women with each other and to discuss with them their duties as hostesses at the 1950 Convention. The enthusiasm displayed insures a successful program. Mr. T. N. Bath acted as a target for questions pertaining to various phases of the lubricants problem. Two colored motion picture films were shown illustrating the history of the discovery of oil, the geology of productive oil well territory, methods of drilling and pumping. The October meeting, held at the Engineering Society of Detroit, engendered much enthusiasm with their 3-Panel Discussion. The subject covered General Plant Lubrication Practices. The speakers, well known in the field of lubrication, were:

Mr. Orvil Hoover, Master Mechanics Division, Dodge Main Plant, Discussion Leader.
Mr. Morgan Lawton, Lincoln Engineering Co., Lubrication Equipment.
Mr. John Kolb, Sun Oil Company, Liquid Lubricants.
Mr. John Rosnell, The Texas Company, Greases.

Each of these men very capably handled their assignments. Mr. E. S. Kelley, Vice Chairman of the Section, has cooperated in submitting the above report.

For additional Convention information, see the ½-page ad in this issue which was designed by the Detroit group, who are also bearing the expense of this ad.

LOS ANGELES

A "Stump the Experts" meeting in September, composed of a panel of three outstanding lubrication engineers, each of whom has a technical education coupled with a rich background in the practical application of industrial lubricants, successfully met a barrage of questions from the floor. Mr. Phil S. Adams, Chief Industrial Lubrication Engineer of the General Petroleum Company, answered questions dealing with Industrial Lubricating Oils. Mr. J. F. Lyons, Lubrication Engineer of the Texas Company, handled Industrial Greases, Gear Oils and Compounds. Mr. Arthur D. Brobbs, Pacific Coast Representative of the Lubrizol Corp., replied to the queries on Additives Used in Industrial Lubricants. After a preliminary outline

of the principles and fundamentals of each of the above subjects, by the individual who was to answer questions on that phase, the meeting was open for discussion. The problems of lubrication of industrial and automotive gears, the AN 2-104B oils and the Supplement I and Series II lubricants of that specification, the use and purpose of additives, and questions concerning turbine oils and industrial low-temperature greases were discussed. The session was considered extremely informative and profitable and another, along this line, is being planned for the near future. Mr. T. W. Russell has been appointed Field Editor to replace Mr. Arthur Montzheimer who has returned to the east. Mr. C. L. Pope, Chief Lubrication Engineer of the Eastman Kodak Company, and President of A.S.L.E., spoke at the October meeting. President Pope is eminently qualified to discuss the scope, qualifications, and requirements of a lubrication engineer. His talk was well illustrated by slides and covered the various phases of plant lubrication. Mr. Perso, Secretary of this Section, presents the high spots of the talk: "Phases of the talk covered grease characteristics such as bleeding, viscosity of grease, grease separations, grease emulsions, and false brinnelling of anti-friction bearings. Mr. Pope pointed out that thick film was the optimum for bearing lubrication. He also brought out that maintenance, inefficient plant personnel, and attitude towards lubrication were the factors which contributed mostly to failures. A point that was brought up which hasn't been given much thought by industry is the disposal of used lubrication oils. Large volumes of oil are used in equipment in the later type of machinery which must be drained periodically. It is the lubrication engineer's responsibility to find ways and means of disposing of these used oils so that rivers, streams, etc., will not become polluted and industry blamed for it. Also, another pertinent point brought out was that in running in new bearings, his experience was to maintain a regular speed to provide a thick oil film when the bearing is new." Report of the November meeting arrived after the publication deadline of this issue. The scheduled meeting for December is the 13th of the month.

CHICAGO

Mr. Robert A. Kraus, Chairman of this Section, graciously reports on the various activities. The first meeting of the current season was extremely well attended. Mr. O. L. Maag, Chief Lubrication Engineer of the Timken Roller Bearing Co., and past President of A.S.L.E., spoke on the subject "Lubricants For Anti-Friction Bearings." Mr. Maag indicated the preferred lubricants for a great number of applications and reviewed the variation in performance as affected by the lubricant. The subsequent discussion period was lively, with considerable emphasis placed on request for information on specific problems. Art Hastings of the Crane Packing Co. was elected Chairman of the Membership Committee. Art did a phenomenal job on individual memberships at the first A.S.L.E. Convention in Chicago and his salesmanship abilities will stimulate the growth of the Chicago Section. Everyone was glad to see him back and again active after a long illness. Mr. James W. Hopkinson, President of the Penn-Petroleum Corp., Detroit, and Chairman of the Detroit Convention Committee for 1950, outlined the activities and preliminary arrangements for the entertainment of members and guests in April. The work that he and his Committee are doing assures excellent reception in Detroit. Mr. L. A. Danse, Supervisor of Materials and Processes, General Motors Corp., and a Director of A.S.L.E., was the speaker at the November meeting. Subject: "Lubrication Progress From Water Wheels to High Speed Machinery." An evening with Mr. Danse always insures interest and zest, with much discussion between Mr. Danse and the audience.

BOSTON

This group started its second year with excellent plans for an active season. The September meeting augured well for the balance of the program. Mr. M. R. Clapp of the Lubrizol Corp. presented "Latest Developments in Gear Lubricants and Motor Oils for Heavy Duty Truck Operations." The outstanding feature of the talk dealt with the load-carrying ability under high torque at low speeds. This paper will later be presented to the S.A.E. in St. Louis and the A.S.T.M. in San Francisco. The following meeting dates have been announced, all to be held on Monday nights, at the Hotel Lenox in Boston:

November 21, 1949 March 20, 1950
January 23, 1950 May 22, 1950

Subjects and speakers for the coming meetings include E. M. Higgins, "Ball and Roller Bearings Lubrication"; F. C. Linn, "Turbine Lubrication"; W. B. Perriguey, "Hydraulic Transmissions"; M. R. Clapp, "Extreme Pressure Lubrication."

PITTSBURGH

Dr. M. E. Merchant of the Cincinnati Milling Machine Co., and a Director of A.S.L.E., presented a very instructive talk on "Action of Cutting Fluids in Machining." A lively discussion followed Dr. Merchant's talk. The meeing ended with a short movie of "The Physics of Metal Cutting." Reports of the various officers and future plans, including a repetition of a plant tour, provide an optimistic note for a highly successful season for this group. Mr. R. J. S. Pigott, Chief Engineer of the Gulf Research and Development Corp., was the speaker at the second meeting. Subject: "Lubrication." Mr. Pigott discussed bearing design as it is related to automotive engine development and some of the factors involved in piston ring friction and lubrication. He showed machine changes being used at Gulf for studying some of the variables in ring lubrication. The November 18th meeting was a "Stump the Lubrication Experts" program. We are indebted to Mr. P. R. Eklund of the Westinghouse Electric Corp. for his excellent resumes.

INDIANAPOLIS

Mr. Carl E. Schmitz of Crane Packing Company, Chicago, and newly elected Treasurer of the A.S.L.E., presented a paper entitled "The Importance of the Mechanical Seal to the Lubrication Engineer," before the October meeting of this Section. Mr. Schmitz is an authority on the subject of seals and his presentations are always highly interesting and informative.

MILWAUKEE

A combination meeting of the Engineers' Society of Milwaukee and the American Society of Lubrication Engineers sponsored an unusual program, "Occupational Dermatitis—Today's Challenge to Industrial Medicine," by Walter F. Schlotz, Supervisor of Industrial Hygiene at Allis-Chalmers, and Dr. Clifford H. Kalb, Clinical Allergist of Milwaukee. This was the story of how two professions work together to battle occupational skin diseases. The doctor-engineer team evoked much interest.

(*Continued on page* 295)

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Membership in the Society is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

MEMBERS—$12.50

Members shall be: (1) persons not less than twenty-four years in age who are engaged in research and instruction at technical schools, universities and various publicly and privately supported institutions in the field of lubrication; or (2) persons not less than twenty-four years in age who have occupied recognized positions as Lubrication Engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) persons not less than twenty-four years in age who are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge and accomplishment, have manifested a particular interest in the purposes and welfare of the Society, to the extent that their membership would be a valuable contribution to the successful functioning of its activities.

JUNIOR MEMBERS—$6.25

Junior Members shall be: persons less than twenty-four years in age, and those who do not completely fulfill the membership requirements for Members.

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Industrial members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. The fees paid by an industrial member in general will not be allowed to exceed $200.00 per year.

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*Denotes Residence Address Preferred.

NEWS of the SECTIONS

(*Continued from page* 293)

PHILADELPHIA

The first meeting of the 1949-50 season found the Philadelphia Section putting on a "Question and Answer" program. The panel of experts included:

Mr. D. F. Hollingsworth, The du Pont Company.
Mr. C. Shaeffer, Bethlehem Steel Co.
Mr. A. Renno, The Texas Company.
Mr. J. Dunham, Tide Water Associated Oil Co.
Mr. P. Teal, The Alemite Company.
Mr. M. Hazenfield, Lincoln Engineering Co.
Mr. H. Moore, Walter Kidde Company.

Mr. Wm. P. Kuebler of Westinghouse acted as moderator; Dr. E. S. Ross of Sun Oil and Mr. C. Warnecke served as judges and distributed prizes to the questioners who succeeded in "stumping the experts." Many of the questions evoked a spirited discussion among those in attendance. Thanks to Mr. William Eismann, Jr., Secretary of this Section, for reporting the above.

CLEVELAND-YOUNGSTOWN

OCTOBER MEETING
"Stump the Experts"
PANEL:

Mr. G. F. Fenker, Pennsylvania Refining Co. (Oil)
Mr. A. R. Allison, Stevens Grease & Oil Co. (Grease)
Mr. M. R. Clapp, Lubrizol Corp. (Additives)
Mr. L. H. Stranahan, White Motors. (Automotive)
Mr. E. Crankshaw, Cleveland Graphite Bronze. (Bearings, Plain)
Mr. R. J. Hagan, Republic Steel Corp. (Industrial)

QUIZ MASTER:

Mr. W. F. Leonard, National Sec'y

JUDGES:

Mr. C. A. Bierlein, Cleveland Diesel, Div. G. M.
Mr. N. I. Whiteley, American Steel & Wire Co.
Mr. R. T. Davidson, Sun Oil Company.

At this meeting, if the gentleman on the panel could not solve the problem satisfactorily, in the opinion of the judges, a silver dollar was awarded to the individual who originally asked the question. Mr. C. E. Pritchard of Republic Steel Corp., and past President of A.S.L.E., seemed to have a corner on collecting the silver dollars. Comments were being tossed around to the effect that since he had successfully raised the money to buy shoes for the latest newcomer in his family, it might have been advisable for him to retire and give someone else a chance. It was a most enthusiastic, spontaneous, and enlightening evening. November meeting: "Principles of Lubrication as Illustrated by Transparent Models" was presented by Mr. A. A. Raimondi of Westinghouse Research Laboratories, East Pittsburgh, Pa., in Youngstown. The talk included demonstrations of models illustrating laws of dry and fluid friction and how these principles are applied to thrust and journal bearings. A 16-mm colored film was used to illustrate the talk. The next meeting of this Section will be held in Cleveland on January 24, 1950. Mr. Jules Muller, Director of Engineering for the E. W. Bliss Company, will present the paper "Press Lubrication and Maintenance." We thank Mr. O. J. Riss, Secretary of this Section, for his fine and complete report.

BALTIMORE

Just as we approached our deadline, the program for the 1950 season for this Section was received. Space permits listing only the following meetings:

DECEMBER 16, 1949

"Silicone Fluids and Greases as Lubricants" by Robert Bright, Technical Representative, New York Office, Dow Corning Corp., Midland, Michigan.

JANUARY 27, 1950

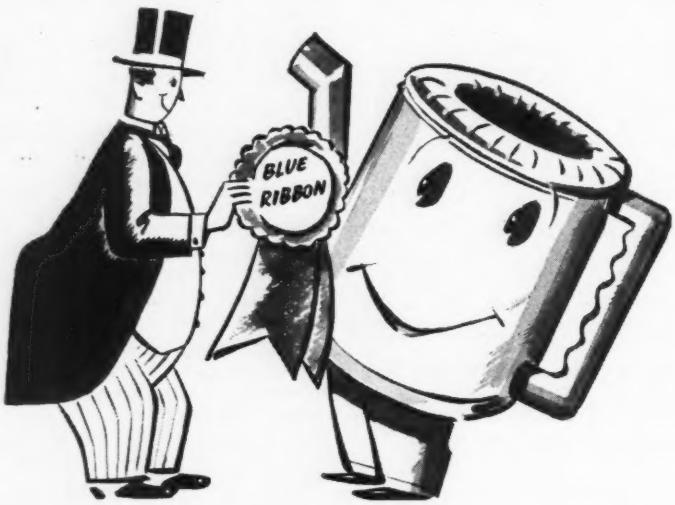
"Maintenance and Lubrication in Steel Plants" by Charles R. Hand, Asst. Supt., Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.

Meeting Place—Sears Community House.

Time—8:00 P. M.

The balance of the program will be published in our February issue.

(*Continued on page* 297)



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Oronite Lube Oil Additives help heavy duty and premium motor oils pass the test of tough operating conditions in modern high speed engines. These superior additives are inhibitors of corrosion and oxidation. They impart to base oils any degree of detergency desired. The excellent qualities of these additives have been proved by extensive field service experience. If you need complete, balanced additives ready for blending or special additive formulations, call or write the Oronite office nearest you.

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Book Reviews

Elements of Diesel Engineering

By Orville L. Adams, Sr.
Norman W. Henley Publishing Company, Inc., New York, 1949. 367 pages. Price $5.00.

This book presents and explains the basic principles underlying the development and operation of diesel engines. It is written at a level such that one not familiar with the subject can read and understand the book without previous preparation. The mathematical developments are carefully illustrated and explained.

The book is characterized by a series of line diagrams and a wealth of illustrative examples. Although designed as a textbook for elementary classroom presentation, the reader should have no difficulty in studying the book without a teacher. A certain amount of fundamental theory common to the operation of all heat power equipment is included in the text.

The book appears to be most applicable for classes at the trade school level or for an introductory survey course at early college level. Each chapter has a series of questions and answers following the text of the chapter.

A discussion of lubrication and lubricating problems is briefly supplied in the text.

Analysis and Lubrication of Bearings

By Milton C. Shaw, Department of Mechanical Engineering, Massachusetts Institute of Technology; and E. Fred Macks, Lewis Flight Propulsion Laboratory, NACA.
McGraw Hill Book Company, New York, 1949. 618 pages. Price $10.00.

This book represents an outstanding contribution to the theory and practice of lubrication and bearings. In fact it is really the first definitive text at advanced level in the English language.

The authors have drawn freely upon the lubrication literature and interpreted the results with an easy-to-understand style of writing which in no way ignores the mathematical rigor required for a full comprehension of the topics discussed.

In this reviewer's opinion, the authors have well accomplished the objectives they mention in their Preface, from which I quote:

"In previous lubrication texts it has been customary to ignore the kinematic and dynamic conditions under which most shaft bearings actually operate. The bearing considered has usually been one which operates at a constant speed while subjected to a load that varies neither in magnitude nor direction. However, in this book the external conditions imposed upon representative shaft bearings have been considered in detail and integrated with lubrication theory according to the following plan. The general principles of bearing load analysis are first developed, and a number of representative examples are discussed. Dimensional analysis is then introduced to generalize the results of bearing-load computations and lubrication theory. A series of chapters is devoted to the principles and problems of hydrodynamic lubrication, followed by a discussion of rolling-contact bearings. The many variables of importance in boundary lubrication are considered next. The final chapter is devoted to a brief description of a representative group of bearing test machines."

The book is enriched with a wealth of completely worked out illustrative examples and in addition a number of problems for practice solution are also supplied. A very complete bibliography is addended which is valuable in itself.

Both for the student and the engineer concerned with problems of lubrication and bearings, this book is a "must" for the library.

B. H. JENNINGS

(*Continued from page* 295)

DAYTON SECTION IN RETROSPECT

Immediately following an inspiring National Meeting of the ASLE in Pittsburgh in 1946, a small group of men under the leadership of Bob McKibben, Lyle Brace, and Virgil Hutton met in the Engineers Club of Dayton with the purpose in mind of organizing a local section. It was felt that the Dayton area would not only be receptive to the establishment of a local section, but would be desirous of deriving the many benefits involved in the participation of such an organization.

A general meeting in the latter part of 1946 was held at the Engineers Club, which was attended by over 70 people. On the basis of such a response from the residents of this area, negotiations were initiated with the National ASLE to obtain recognition and a charter. Aided in this determination by the then National President, Oscar L. Maag, a charter was granted, and a special meeting on October 16, 1947 ratified the Dayton Section Constitution. The Dayton Section then became the 12th in the official family of the National Society. From the date of its inception to the annual meeting in May, 1949, there has been a membership increase of 275%. Approximately 50% of the membership comprises producers and marketers; while the remaining 50% are consumers and professional men. The reason for the good balance may be seen from the diversity of the various activities within the Dayton area. The current membership contest with the Chicago Section will do much to aid the membership picture.

The Dayton Section includes a highly industralized area. This industry varies widely in nature from heavy industry to light and intricate industry. Within its borders lie the heart of the machine tool industry, that builds the tools, with which all other manufacturing is carried out. The process industries also hold a prominent place in this area.

In the center of our area lies Wright Field with its vast laboratories for design, development and evaluation of aircraft, its equipment and materials of construction. Last but far from least is the academic influences in our section. The University of Dayton, University of Cincinnati, Ohio State University, Antioch College, and many other schools of higher learning provide us with a wealth of educational facilities.

All of the above phases of industry, research, and education are mutually tied together. These diversified groups find lubrication to be a common problem. Industry depends on research and education to provide for it the fundamentals of lubrication in a manner which can be usefully applied. On the other hand, the research and educational institutions depend on a smooth running, prospering industry for their existence.

The area is well serviced by the technical representatives of all the major oil companies and many of the minor ones. They contribute much, not only by recommending suitable lubricants, but suitable practice as well.

The Dayton Section in supporting the original purposes of the ASLE has established itself as a clearing house of lubrication information in this area; has brought together representatives from the various fields of endeavor, that they may obtain a better understanding of their mutual problem, lubrication; and has made every effort to advance the science of lubrication in this area. Many goals, such as the annual publication of a Yearbook, have been reached, but only with increased effort and greater dissemination of information, regarding the benefits to be derived from "lubrication engineering," will this section be able to make its mark in this community, and be a credit to the National Society.

A.S.L.E. MEMBERSHIP LISTS

This year we have printed and bound, separately, the annual membership roster of our Society. It has been enclosed with the December issue to each member. Copies are available upon request to the National office, to subscribers and advertisers, provided use is not made of the lists for solicitation or other advertising purposes.

"LUBRICATION ENGINEERING"

How valuable can it get? Subscription rate is $4.00 per year. One of our subscribers from Batavia, Indonesia, sent to the National A.S.L.E. office a check for $23.50 to cover air mailing of each number for one year.

OUR COVER

Dayton's history is steeped in the lore of the pioneers. Across its pages have marched some of America's greatest heroes—George Rogers Clark, Simon Kenton, Daniel Boone, "Mad Anthony" Wayne and others—pioneers of discovery and exploration. A generation later, the pioneers of business and industry—John H. Patterson, Charles F. Kettering, E. A. Deeds—came upon the scene and wrote still another stirring chapter of history.

Known as the birthplace of aviation, Dayton is still the center of aeronautical research in America. The Air Materiel Command, located at Wright and Patterson Fields, is the research ground for all Army aviation. The Command also has charge of all supply for the Army Air Forces. Named after the inventors of the airplane, Wright Field is a gift to the United States government of Daytonians, who, in two days' time, raised $250,000 with which to purchase nearly 5,000 acres of land. Although Dayton is a highly diversified, industrial city, it has proved it can also be beautiful. Its greatest asset is its people who are proud of their city and interested in its welfare and development. Working together in peace and harmony, they face the future with confidence, their sights set on an even greater, more progressive, more prosperous city.

DIRECTORS MEET

At the September 16, 1949 Board of Directors meeting held at Hotel Bismarck, Chicago, Mr. Carl E. Schmitz, Crane Packing Co., Chicago, Ill., was elected Treasurer of the Society. Plans were discussed for participation in the Cleveland Plant Maintenance Show in January. It was voted to have proper certificates of membership prepared for sale to our members. These are now under way and a full description is given on another page. The city of Philadelphia was named as the site of the 1951 A.S.L.E. Convention and Exhibit.

OILS AND LUBRICANTS PATENT ABSTRACTS

Lubricants—Patent #2,480,873—John M. Musselman, assignor to The Standard Oil Company.
A lubricating oil composition comprising a major amount of lubricating oil, from about 0.01 to about 25% of the reaction product obtained by reacting, an oil-soluble oxygen-containing organic compound selected from the group consisting of fatty acids and fatty acid esters with a phosphorous sulfide at a temperature from between about 175°F. to about 450°F. and in amounts such that the weight of the sulfur in the phosphorus sulfide is about double the weight of the oxygen in said organic compound and from about 0.01 to about 25% of an oil-soluble detergent selected from the class consisting of organic sulfonates and organic sulfates.

Lubricating Composition—Patent #2,481,257—Miller W. Swaney and George E. Serniuk, assignors to Standard Oil Development Co.
A lubricating composition consisting essentially of a mineral lubricating oil and from 0.05 to 10 weight per cent based on the oil of an oil-soluble condensation product, obtained by condensing with aid of a peroxide catalyst of from 50 to 80 parts of a vulcanizable rubbery hydrocarbon polymer prepared by the polymerization in aqueous emulsion, said polymer being selected from the group which consists of polybutadiene-1, 3 and copolymer of butadiene-1, 3 with a monomer containing a polymerizable vinyl group, and 50 to 700 parts of a primary aliphatic mercaptan containing from 8 to 18 carbon atoms per molecule, said condensation occuring at a temperature ranging from 50 to 60°C., said condensation product having a sulfur content in the range of 6.18 to 10.6 weight per cent.

Crankcase Conditioning Oil—Patent #2,481,268—C. Newbold Watson, assignor to Standard Oil Development Co.
A lubricating composition having cleansing properties consisting essentially of mineral base lubricating oil of internal combustion crankcase lubricating grade, containing about 20% of a composition of the following approximate proportions by weight:

	Percent
Oil soulble sodium petroleum sulfonate	11
Sodium Naphthenate	3
Diethylene glycol	1
Aromatic solvent naphtha of boiling range about 300° to 370°F.	35
Mineral oil of about 80 SSU viscosity at 210°F.	5
Phenol extract of Coastal naphthenic oil of about 500 SSU viscosity at 100°F.	45

Rust Protective Lubricants—Patent #2,481,372—George Hugo von Fuchs and Gerhard P. Pilz, assignors to Shell Development Co.
A liquid lubricating composition consisting essentially of a predominating amount of an ester of an aliphatic dicarboxylic acid and of an aliphatic monohydric alcohol having 2 to 20 carbon atoms and as an anti-corrosion agent therefor from 1% to 4% by weight of an acid of the group consisting of fatty acids having at least 7 carbon atoms, sulfurized unsaturated monocarboxylic acids having at least 7 carbon atoms, and alkyl phosphoric acids having at least 10 carbon atoms in an alkyl substituent.

Lubricating Composition—Patent #2,481,487—David E. Adelson, assignor to Shell Development Co.
A composition comprising a major amount of an oleaginous material and a minor amount, sufficient to stabilize said oleaginous material against deterioration and corrosion, of a reaction product obtained by initially treating cyclic ketone fractions having at least 12 carbon atoms with phosphorus sulfide at a temperature not in excess of 200° and thereafter treating said reaction product with a sulfurizing agent at a temperature below 180°C., said final reaction product containing from about 1.2% to 5.2% phosphorus and from about 32% to 73% increase in sulfur above that present in the initial reaction product.

Lubricating Oil Composition—Patent #2,481,585—Michael W. Freeman.
A lubricating oil composition having incorporated therein in an amount sufficient to impart extreme pressure properties to said lubricating oil of a complex reaction product obtained by coreacting, at a temperature ranging from room temperature to the boiling point of the component parts of said reaction, (a) 1 to 5 moles of an organic nitrogen base with about 1 mole of an organic monocarboxylic acid and (b) an oxidized mixture of from 1 to 20 moles of an organic sulfonate and a hydrocarbon lubricating body in an amount sufficient to solubilize said organic sulfonate, said portion (b) of the reaction containing not less than 1% of reacted oxygen.

Lubricating Means for Comb Bars and Bobbin Shuttles for Lace Looms—Patent #2 482,425—Edward W. Medbery, assignor to Marshall Field & Co.

Printed copies of patents are available from the Patent Office at twenty-five cents each. Address the Commissioner of Patents, Washington, D. C., for copies and for general information concerning patents.

From Official Gazette—Vol. 626, Nos. 1, 2, 3, 4; Vol. 627, Nos. 1, 2, 3, 4.

Prepared by ANN BURCHICK

Lubricating means for traveling bobbin shuttles for lace looms comprising in combination a base member, means whereby the base member is secured to the loom, an oil reservoir on said base member, a capillary oil conveyor extending into the oil reservoir and into the path of travel of the bobbin shuttles whereby intermittent engagement of the said oil conveyor and bobbin shuttles is obtained by the oscillating of the bobbin shuttle and means intermediate its ends whereby the said capillary oil conveyor is held onto the said base member.

Corrosion Inhibiting Composition—Patent #2,482,517—Knapel F. Schiermeier and Walter E. Heinz, assignors to Shell Development Co.
A homogeneous, storage-stable solution in an essentially hydrocarbon medium of a corrosion-inhibiting amount of a partial ester of an acyclic polyhydric alcohol an aliphatic acid having from 10 to 40 carbon atoms, said partial ester having the following properties: a melting point below about 200°F., a solubi.ity in said medium below that enabling dissolution of said amount at normal room temperature in the absence of a mutual solvent, a ration of hydroxyl to ester radicals of at least 1:1, a content of at least 12 carbon atoms and of at least 2 hydroxyl radicals separated from each other by not more than 3 directly connected atoms, said solution additionally containing an oil-soluble salt of an organic sulfonic acid in an amount sufficient to maintain the ester in solution under normal storage conditions.

Lubricating Means for Bearings and Spindles or Shafts—Patent #2,482.536—Ettore Bugatti.
A self-contained, shaft bearing and lubricating unit which comprises the combination of a tubular rigid member with substantially continuous, smooth inner and outer cylindrical peripheries, said member having in its annular wall a longitudinal inner channel co-extensive therewith, an inner chamber located substantially midway between the ends of said member, adapted and arranged to communicate with said channel, and an inner lubricant delivering duct from said chamber to the inner periphery of said member substantially midway between the ends thereof; and a lubricant pump supported and confined in said chamber, adapted to force lubricant from said channel into said duct.

Lubricating Compositions—Patent #2.482.762—Mayer B. Goren, assignor to Shell Development Co.
A composition comprising a major amount of a liquid hydrocarbon and a minor amount, sufficient to stabilize said liquid hydrocarbon against deterioration and improve its anti-wear properties, of a stable, non-corrosive phosphorus and sulfur-containing reaction product obtained by reacting, at a temnerature ranging from 130°C. to about 200°C., phosphorus sulfide and a cyclic ketone fraction having at least 12 carbon atoms the ratio of the phosphorus sulfide to the ketone compound being 1:4 to about 1:8 respectively.

Lubricating Composition—Patent #2.483.270—Paul W. Fischer, assignor to Union Oil Co. of California.
A composition of matter adapted for addition to lubricating oil consisting of an oil-soluble metal salt of the reaction product of a phosphorus compound of the class consisting of phosphorus sulfides and phosphorus oxides with a petroleum sulfonic acid, said reaction product being obtained by reacting said sulfonic acid with between about 3% and about 50% by weight of said phosphorus compound at temperatures between 100°F. and 400°F.

Lube Oil Additives and Preparation Thereof—Patent #2,483,499—Eugene Lieber and Aloysius F. Cashman, assignors to Standard Oil Development Co.
The process which comprises reacting a paraffin wax sulfonyl chloride having at least two chlorine atoms with a monomeric condensed polynuclear aromatic hydrocarbon in the presence of a Friedel-Craft catayist, using a final reaction temnerature of about 100° to 400°F., to produce high molecular weight polymeric sulfone compounds, hydrolyzing and removing residual catalyst, and distilling the reaction products under reduced pressure to obtain the desired condensation product as distillation residue.

Compounded Lubricating Oil—Patent #2,483,505—Dilworth T. Rogers and John G. McNab, assignors to Standard Oil Development Co.
A compounded lubricant comprising a mineral lubricating oil base and 0.02% to 20% of a product obtained by reacting elemental sulfur with a basic polyvalent metal salt of an alkylated phenol sulfide having at least 5 carbon atoms in each alkyl group at a temperature of 90° to 210°C., the proportion of reactants being such that 0.1 to 2.5 atomic proportions of sulfur are present for each atomic proportion of metal.

Tall Oil Acid Composition—Patent #2,483,797—Edward A. Van Valkenburgh.
A tall oil acid composition containing from about 10 to 90% of the aliphatic amine soaps of tall acids and from about 90 to 10% of free tall oil acids, said composition being free from uncombined amine.

Grease Composition—Patent #2,483,800—John C. Zimmer and Gordon W. Duncan, assignors to Standard Oil Development Co.
A grease composition comprising a major proportion mineral base lubricating oil and sufficient of the complex reaction product of an oil-soluble salt of a sulfonic acid having a molecular weight of approximately 300 to 600 and a water-soluble salt of an inorganic acid in which at least one cation in the above salts is polyvalent said salt being substantially free of chloride ions to thicken the mineral oil to a grease consistency.

Quick-Breaking Emulsions Having Increased Adhesion to Mineral Aggregate—Patent #2,483,835—Donald N. Manzer, assignor, by mesne assignments, to Stancal Asphalt & Bitumuls Co.
A quick-breaking oil-in-water type emulsion consisting essentially of water, a water-insoluble, water-dispersible, organic, thermoplastic, resinous substance emulsified therein, and a small amount of a preformed alkali metal ammonium chromate salt sufficient substantially to promote adhesion of the emulsified substance to hydrophilic aggregate.

Emulsion Product and Process of Making—Patent #2,483,836—Paul E. McCoy, assignor, by mesne assignments, to Stancal Asphalt & Bitumuls Co.
In the process of making a flowable, stable, storable, non-tacky, weather-resistant coating composition, the steps comprising forming an oil-in-water type emulsion having water as its continuous phase and having as its dispersed phase 50-70% of its weight of a water-insoluble, water-dispersible, organic thermoplastic material, incorporated in said emulsion a filler and, based on the total weight of the coating composition, 0.2-20% of a polyvalent metal fluosilicate, having a solubility in water at 20°C. greater than about 1.0%, and 1.0-12% of a water-soluble alkali metal inorganic salt of the type which reacts in aqueous solution with water-soluble polyvalent metal fluosilicates to form a water-insoluble polyvalent metal salt, and forming said water-insoluble alkali metal fluosilicate and water-insoluble polyvalent metal salt in situ in said coating composition.

Antiring Sticking Lubricating Composition—Patent #2,483,859—Mintje van Loon, assignor to Shell Development Co.
A lubricating composition comprising a mineral oil containing dispersed therein from 0.5% to 20% of a polyvalent metal salt of a reaction product obtained by simultaneously polymerizing and alkylating in the presence of a Friedel-Crafts catalyst a hydroxy aromatic monocarboxylic acid and an olefin having at least four carbon atoms at a temperature of between 50° to 200°C., and thereafter reheating said reaction product in an inert liquid medium at a temperature of between 250° and 300°C. for about ½ hour.

Lubricating Composition—Patent #2,484,146—Sidney J. Barber and James T. Eaton, assignors to E. F. Houghton & Co.
A single phase lubricating composition consisting essentially of a lubricant selected from the group consisting of mineral oil, a mixture of mineral oil and not more than about 50% of saponifiable oil based on the mineral oil and a mixture of mineral oil and not more than about 35% of a metal soap jelling agent, and from about 2% to about 25% of a phosphoric acid salt, soluble in said mineral oil, of a condensation product of one mol of an amine, selected from the group consisting of polyalkyleneamines having from three to five amino groups, alkylol amines having from two to three hydroxyl groups and alkylolpolyamines having from two to three amino groups, the alkylene and alkylol units having two to four carbon atoms, with two mols of a higher fatty acid selected from the group consisting of the acids whose formulae are represented by $C_nH_{2n} + 1COOH$ wherein n is at least 11, oleic, linoleic and ricinoleic acids.

Method of Modifying Castor Oil—Patent #2,484,328—Melvin Agster and Robert L. Terrill, assignors to Spencer-Kellogg and Sons, Inc.
The method of modifying castor oil which comprises partially dehydroxylating the oil by heating the same at temperatures within the range 460°F. to 520°F. in the presence of a lead compound soluble in castor oil at about 300°F. in an amount within the range 0.5% to 0.1% calculated as PbO to reduce the acetyl value to within the range 60 to 100 and raise the iodine value to within the range 95 to 105 whereby the resultant oil is non-drying and miscible in mineral oil.

Lubricant Composition—Patent #2,484,843—John M. Musselman, assignor to The Standard Oil Co.
As a composition of matter suitable for use as a lubricant and as an addition agent to improve the characteristics of lubricating oils and greases, the reaction product of hydrogenated sperm oil hydrogenated to an iodine value of not over 40 with about 15 to 25% phosphorus pentasulfide, reacted at a temperature within the range of about 275 to 400°F. to form said reaction product.

Method of Modifying Glyceride Oils—Patent #2,484,979—George Barsky assignor to E. F. Drew & Co., Inc.
A method of treating non-hydroxylated mixed glyceride non-drying oils to change the chemical composition thereof which comprises adding to said oil a relativvely small amount of boric acid, heating the mixture for a sufficient length of time at a sufficiently high temperature to liberate free fatty acids from the oil, distilling said acids from said mixture and substantially freeing the residue from combined boric acid.

Lubricated Wire Rope—Patent #2,485,019—Peter P. Somerville, assignor to Jones & Laughlin Steel Corp.
Lubricated wire rope comprising strands wound together and lubricant comprising an oleaginous carrier containing powdered bearing metal covering the strands to lubricate them with respect to one another and to externally lubricate the rope.

Quenching Oil and Method for Quenching Metals—Patent #2,485,103—Gerard S. Mapes and Louis H. Sudholz, assignors to Socony-Vacuum Oil Co., Inc.
An improved method for quenching heated metals which comprises quickly immersing said heated metal in a fluid bath consisting principally of alkyl-substituted polynuclear aromatic hydrocarbons boiling within the range 550°F. to 800°F.

Corrosion Preventive Composition—Patent #2,485,321—Knapel F. Schiermeier, assignor to Shell Development Co.
A composition of matter adapted for use as a rust inhibitor containing the following components in the following proportions:

Additive	% by Weight
Asphaltic bitumen	35-75
Fixed oil	2-10
Waxy hydrocarbon	5-25

said component mixture being diluted with a major amount of a light liquid hydrocarbon.

Rust Inhibiting Composition—Patent #2,485,341—Jones I. Wasson and James W. Hand, Jr., assignors to Standard Oil Development Co.
A composition consisting essentially of a mineral lubricating oil base containing dissolved therein 0.05 to 5% by weight of a member of the class consisting of sorbitan mono-oleate and pentaerythritol mono-oleate, and 0.05 to 3% by weight of a member of the class consisting of tributyl phosphite and tri-p-tert.-butylphenyl phosphite.

Corrosion-Resisting Lubricating Compositions—Patent #2,485,376—Frank J. Glavis and Harry T. Neher, assignors to Rohm & Haas Co.
Composition of matter consisting essentially of a diester of a saturated aliphatic dicarboxylic acid of six to ten carbon atoms and an aliphatic monohydric alcohol of four to fourteen carbon atoms in which there is dissolved from 1% to 7.5% of an oil-soluble petroleum sulfonate and from 0.5% to 2% of an oil-soluble alkylphenoxypolyethoxyethanol having an alkyl group of four to twelve carbon atoms and having three to five ether linkages, the amount of diester, sulfonate, and alkylphenoxypolyethoxyethanol totalling 100%.

Lubricating Oil—Patent #2,485,861—Sumner E. Campbell and Ilo S. Dellinger.
An internal combustion engine compounded lubricating oil consisting essentially of a lubricating grade hydrocarbon oil containing a permanent dispersion of an alkaline inorganic compound of the group consisting of the hydroxides and carbonates of an alkali earth metal, and an oil soluble mahogany sulfonate in sufficient quantity to serve as a dispersing agent for said compound, said compounded oil having an alkali neutralization number as herein defined between 0.50 and 3.0.

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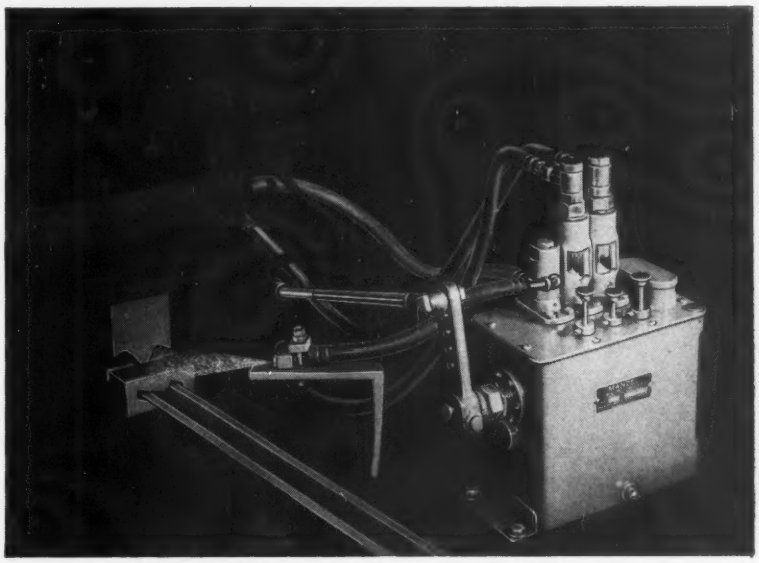

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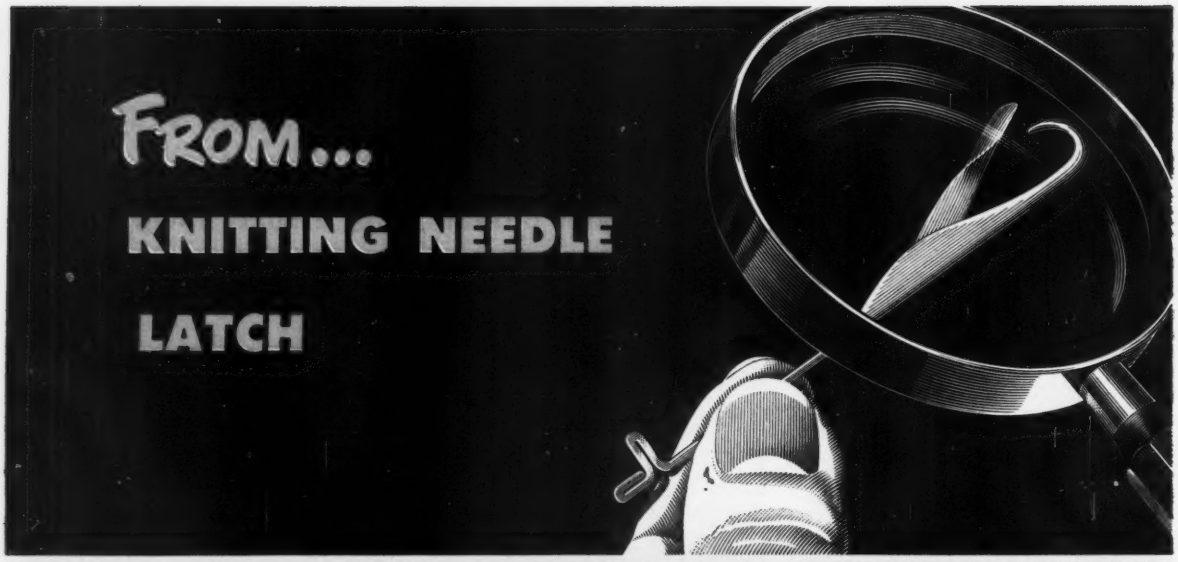

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(*Continued from page* 282)

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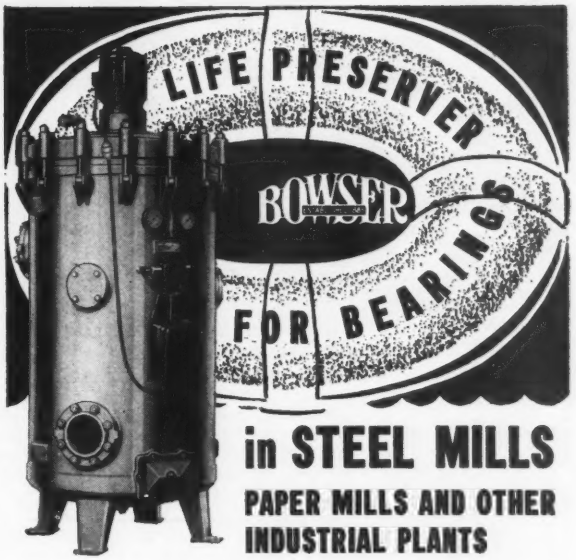

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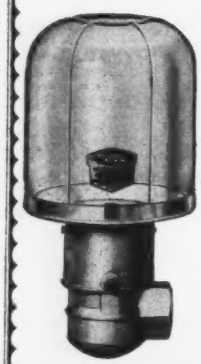

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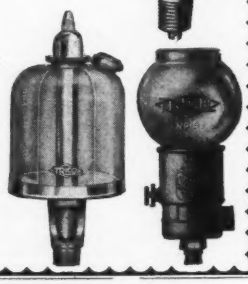

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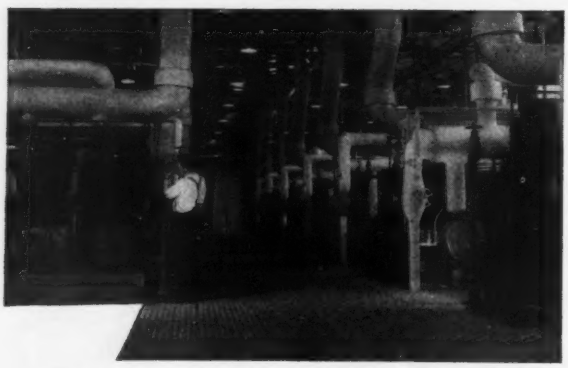

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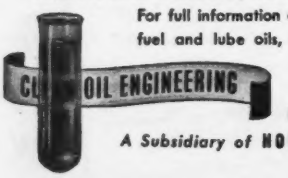

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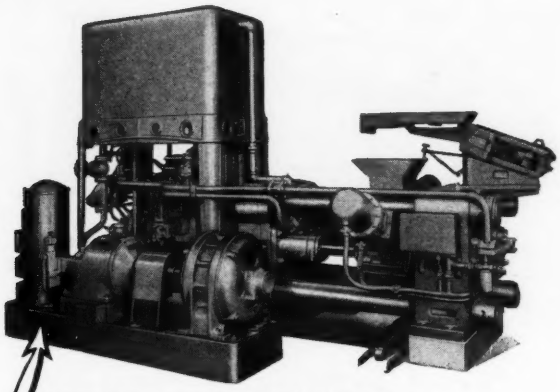

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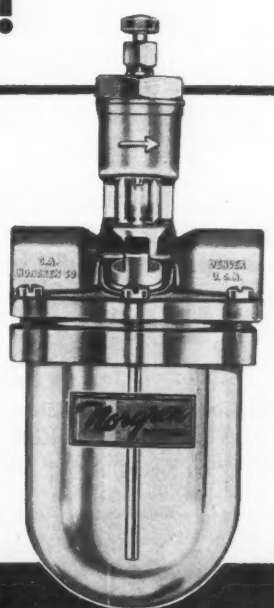

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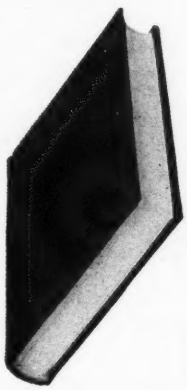

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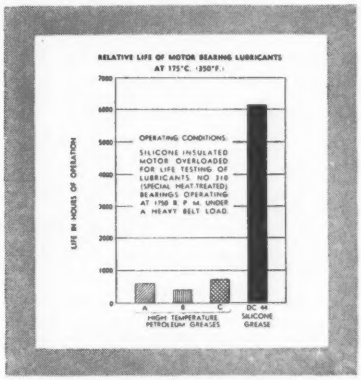
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SUBJECT AND AUTHOR INDEX

This index includes all material appearing in Volume 5 (February, April, June, August, October and December, 1949)

LUBRICATION ENGINEERING — *Names of authors are in small capitals*

A

	NO.	PAGE
ABC's of Lubrication Grease, GEORGE W. MILLER	6	274
Accidents, Preventing, by Proper Lubrication, WALTER E. MONTGOMERY	3	134
Anti-Friction Bearings, Greases — Their Uses in, J. H. GUSTAFSON	6	281
Anti-Friction Bearings Pay Dividends on Textile Machinery, CARL A. BERG	6	273
Application, Grease, to Mining Machinery, MORGAN B. LAWTON	6	278
Applications, Grease Lubrication in Machine Tool, E. RALPH HARRIS	6	276

B

BARR, WILLIAM M., Biography of	4	168
BARR, WILLIAM M., Lubrication of Railway Rolling Stock	4	168
Bearings, Anti-Friction, Greases — Their Uses in, J. H. GUSTAFSON	6	281
Bearings, Anti-Friction, Pay Dividends on Textile Machinery, CARL A. BERG	6	273
Bearings, Dynamically Loaded, MILTON C. SHAW	5	218
Bearings, Roller, Improved High-Speed, DONALD F. WILCOCK and FREDERICK C. JONES	3	129
BERG, CARL A., Anti-Friction Bearings Pay Dividends on Textile Machinery	6	273
BIDWELL, JOSEPH B., Discussion of Shaw, Milton C., Paper	5	224
BIKERMAN, J. J., Reply to Discussions of Needs, J. J., Morgan, Frank, and Roess, L. C. (Oct. 1948)	1	27

C

CARMICHAEL, E. S., Biography of	1	15
CARMICHAEL, E. S. — See ROEHNER, T. G.	1	15
CRANKSHAW, E., Discussion of Read, Granville M., Paper	3	124
CROTTY, JOHN R., Biography of	2	73
CROTTY, JOHN R., Lubrication of Textile Equipment	2	71
CUNNINGHAM, J. M. — See Pigott, R. J. S.	5	222
Cylinder Lubrication, Diesel, Some Aspects of, E. B. WATSON	4	180

D

DANSE, L. A., Discussion of Read, Granville M., Paper	3	125
DEUTSCH, L. W., Use of Grease in the Steel Industry	6	278
Development of Grease Lubricating Systems, A. J. JENNINGS	6	270
Diesel Cylinder Lubrication, Some Aspects of, E. B. WATSON	4	180
Dynamically Loaded Bearings, MILTON C. SHAW	5	218

E

EP Gear Oils, Laboratory Evaluation of, L. B. SARGENT, JR., I. S. KOLARIK and E. M. KIPP	5	226
EDWARDS, ROY E., Discussion of Shaw, Milton C., Paper	5	223
EHRLICH, MELVILLE, Discussion of Hulme, C. E.; Eismann, William Jr., (Dec. 1948), Roehner, T. G. and Carmichael, E. S., Papers	1	26
Equipment, Textile, Lubrication of, JOHN R. CROTTY	2	71
EVANS, D. N., Discussion of Read, Granville, M., Paper	3	125

F

Fluids, Hydraulic, Non-Flammable, C. M. MURPHY and W. A. ZISMAN	5, 6	231, 264
Friction of Dry and Lubricated Surfaces As Determined by the Stick-Slip Method, The, F. MORGAN, M. MUSKAT and D. W. REED	2	75
FROHMAN, OSCAR, Discussion of Read, Granville M., Paper	3	125
Functional Tests for Lubricants and Their Interpretation, T. G. ROEHNER and E. S. CARMICHAEL	1	15

G

GARIN, P. V., Discussion of Barr, William M., Paper	4	172
Gear, EP Oils, Laboratory Evaluation of, L. B. SARGENT, JR., I. S. KOLARIK and E. M. KIPP	5	226
GISSER, HENRY, Biography of	4	175
GISSER, HENRY, Progress in Instrument Lubrication	4	175
GOEHRING, C. C., Discussion of Read, Granville M., Paper	3	126
GOTHARD, N. J., Discussion of Barr, William M., Paper	4	174
Grease Application to Mining Machinery, MORGAN B. LAWTON	6	278
Grease, Lubricating, ABC's of, GEORGE W. MILLER	6	274
Grease Lubricating Systems, Development of, A. J. JENNINGS	6	270
Grease Lubrication in Machine Tool Applications, E. RALPH HARRIS	6	276
Grease Symposium	6	270
Grease, Use of, in the Steel Industry, L. W. DEUTSCH	6	278
Greases, Significance of Tests and Speeifications for, GUS KAUFMAN	2	83
Greases — Their Uses in Anti-Friction Bearings, J. H. GUSTAFSON	6	281
GURNEY, DANIEL, Discussion of Wilcock, Donld F. and Jones, Frederick C., Paper	4	184
GUSTAFSON, J. H., Greases — Their Uses in Anti-Friction Bearings	6	281

H

HARRIS, E. RALPH, Grease Lubrication in Machine Tool Applications	6	276
HAYES, MATTHEW N., Discussion of Hulme, C. E., Eismann, William Jr. (Dec. 1948), Carmichael, E. S., Papers	1	23
HERSEY, MAYO D., Discussion of Shaw, Milton C., Paper	5	224
High-Speed, Improved, Roller Bearings, DONALD F. WILCOCK and FREDERICK C. JONES	3	129
HULME, C. E., Biography of	1	20
HULME, C. E., Significance of Lubricating Oil Tests, The	1	19
Hydraulic Fluids, Non-Flammable, C. M. MURPHY and W. A. ZISMAN	5, 6	231, 264

I

Improved High-Speed Roller Bearings, DONALD F. WILCOCK and FREDERICK C. JONES	3	129
Instrument Lubrication, Progress in, HENRY GISSER	4	175

J

JENNINGS, A. J., Development of Grease Lubricating Systems	6	270
JENNINGS, B. D., Discussion of Barr, William M., Paper	4	171
JOLLY, T. D., Discussion of Read, Granville M., Paper	3	126
JONES, FREDERICK C., Biography of	3	129
JONES, FREDERICK C. — See Wilcock, Donald F.	3	129

K

KAUFMAN, GUS, Biography of	2	83
KAUFMAN, GUS, Significance of Tests and Specifications for Greases	2	83
KIPP, E. M., Biography of	5	226
KIPP, E. M. — See Sargent, Jr., L. B.	5	226
KOLARIK, I. S., Biography of	5	226
KOLARIK, I. S. — See Sargent, Jr., L. B.	5	226
KUEBLER, W. P., Discussion of Read, Granville M., Paper	3	127

L

Laboratory Evaluation of EP Gear Oils, L. B. SARGENT, JR., I. S. KOLARIK and E. M. KIPP	5	226
LAUDIG, J. J., Discussion of Barr, William M., Paper	4	171
LAWTON, MORGAN B., Grease Application to Mining Machinery	6	278
Loaded Bearings, Dynamically, MILTON C. SHAW	5	218
Lubricants and Their Interpretation, Functional Tests for, T. G. ROEHNER and E. S. CARMICHAEL	1	15
Lubricated and Dry Surfaces, The Friction of, As Determined by the Stick-Slip Method, F. MORGAN, M. MUSKAT and D. W. REED	2	75
Lubricating Grease, ABC's of, GEORGE W. MILLER	6	274
Lubricating Oil Tests, The Significance of, C. E. HULME	1	19
Lubricating Oils, Viscosity-Temperature-Pressure Relationships of, R. T. SANDERSON	6	283
Lubricating Systems, Grease, Development of, A. J. JENNINGS	6	270
Lubrication, Diesel Cylinder, Some Aspects of, E. B. WATSON	4	180
Lubrication, Grease, in Machine Tool Applications, E. RALPH HARRIS	6	276
Lubrication, Instrument, Progress in, HENRY GISSER	4	175
Lubrication Means to Management, What, GRANVILLE M. READ	3	122
Lubrication, Preventing Accident by Proper, WALTER E. MONTGOMERY	3	134
Lubrication of Railway Rolling Stock, WILLIAM M. BARR	4	168
Lubrication, Steel Mill, Planning a Program, W. M. SCHUCK	1	10
Lubrication of Textile Equipment, JOHN R. CROTTY	2	71

Mc

MCBRIAN, RAY, Discussion of Barr, William M., Paper	4	173

M

MAAG, O. L., Discussion of Barr, William M., Paper	4	200
Machine Tool Applications, Grease Lubrication in, E. RALPH HARRIS	6	276
Management, What Lubrication Means to, GRANVILLE M. READ	3	122
MARSHALL, T. A., Discussion of Read, Granville M., Paper	3	127
MILLER, GEORGE W., ABC's of Lubricating Grease	6	274
Mining Machinery, Grease Application to, MORGAN B. LAWTON	6	278
MONTGOMERY, WALTER E., Biography of	3	134
MONTGOMERY, WALTER E., Preventing Accidents by Proper Lubrication	3	134
MOORE, W. R., Discussion of Roehner, T. G. and Carmichael, E. S., Paper	1	18
MORGAN, F., Biography of	2	75

	NO.	PAGE
MORGAN, F., MUSKAT, M. and REED, D. W., Friction of Dry and Lubricated Surfaces As Determined by the Stick-Slip Method, The	2	75
MURPHY, C. M., Biography of	5	231
MURPHY, C. M. and ZISMAN, W. A., Non-Flammable Hydraulic Fluids	5 6	231 264
MUSKAT, M., Biography of	2	75
MUSKAT, M.—See Morgan, F.	2	75

N

Non-Flammable Hydraulic Fluids, C. M. MURPHY and W. A. ZISMAN	5 6	231 264

O

Oil, Lubricating Tests, The Significance of, C. E. HULME	1	19
Oils EP, Gear, Laboratory Evaluation of, L. B. SARGENT, JR., I. S. KOLARIK and E. M. KIPP	5	226
Oils, Lubricating, Viscosity-Temperature-Pressure Relationships of, R. T. SANDERSON	6	283

P

PIGOTT, R. J. S. and CUNNINGHAM, J. M., Discussion of Shaw, Milton C., Paper	5	222
Planning a Steel Mill Lubrication Program, W. M. SCHUCK	1	10
POPE, C. L., Discussion of Read, Granville M., Paper	3	127
Pressure-Viscosity-Temperature Relationships of Lubricating Oils, R. T. SANDERSON	6	283
Preventing Accidents by Proper Lubrication, WALTER E. MONTGOMERY	3	134
PRITCHARD, C. E., Discussion of Read, Granville M., Paper	3	127
Progress in Instrument Lubrication, HENRY GISSER	4	175

R

Railway Rolling Stock, Lubrication of, WILLIAM M. BARR	4	168
READ, GRANVILLE M., Biography of	3	122
READ, GRANVILLE M., What Lubrication Means to Management	3	122
REED, D. W., Biography of	2	75
REED, D. W.—See Morgan, F.	2	75
ROEHNER, T. G., Biography of	1	15
ROEHNER, T. G. and CARMICHAEL, E. S., Functional Tests for Lubricants and Their Interpretation	1	15
Roller Bearings, Improved High-Speed, DONALD F. WILCOCK and FREDERICK C. JONES	3	129
Rolling Stock, Railway, Lubrication of, WILLIAM M. BARR	4	168
RYAN, VICTOR A., Discussion of Read, Granville M., Paper	3	128

S

SANDERSON, R. T., Biography of	6	283
SANDERSON, R. T., Viscosity-Temperature-Pressure Relationships of Lubricating Oils	6	283
SARGENT, JR., L. B., Biography of	5	226
SARGENT, JR., L. B., KOLARIK, I. S., and KIPP, E. M., Laboratory Evaluation of EP Gear Oils	5	226
SCHMITZ, CARL E., Discussion of Read, Granville M., Paper	3	148
SCHUCK, W. M., Biography of	1	13
SCHUCK, W. M., Planning a Steel Mill Lubrication Program	1	10
SENIFF, R. W., Discussion of Barr, William M., Paper	4	171
SHAW, MILTON C., Biography of	5	218
SHAW, MILTON C., Dynamically Loaded Bearings	5	218
SHAW, MILTON C., Reply to Discussions of Pigott, R. J. S. and Cunningham, J. M., Edwards, Roy E., Bidwell, Joseph B., Hersey, Mayo D.	5	224
Significance of Lubricating Oil Tests, The, C. E. HULME	1	19
Significance of Tests and Specifications for Greases, GUS KAUFMAN	2	83
Some Aspects of Diesel Cylinder Lubrication, E. B. WATSON	4	180
Specifications for Greases and Significance of Tests, GUS KAUFMAN	2	83
Steel Industry, Use of Grease in the, L. W. DEUTSCH	6	278
Steel Mill Lubrication, Planning a Program, W. M. SCHUCK	1	10
STEVEN, GEORGE, Discussion of Hulme, C. E., Eismann, William, Jr. (Dec. 1948), Roehner, T. G. and Carmichael, E. S., Papers	1	26
Stick-Slip Method, The Friction of Dry and Lubricated Surfaces, As Determined by the, F. MORGAN, M. MUSKAT and D. W. REED	2	75
SYMON, B. G., Discussion of Read, Granville M., Paper	3	124

T

Temperature-Viscosity-Pressure Relationships of Lubricating Oils, R. T. SANDERSON	6	283
Tests, Functional, for Lubricants and Their Interpretation, T. G. ROEHNER and E. S. CARMICHAEL	1	15
Tests, Lubricating Oil, The Significance of, C. E. HULME	1	19
Tests and Specifications for Greases, Significance of, GUS KAUFMAN	2	83
Textile Equipment, Lubrication of, JOHN R. CROTTY	2	71
Textile Machinery, Anti-Friction Bearings Pay Dividends on, CARL A. BERG	6	273

U-V

Use of Grease in the Steel Industry, L. W. DEUTSCH	6	278
Viscosity-Temperature-Pressure Relationships of Lubricating Oils, R. T. SANDERSON	6	283

W

WATSON, E. B., Biography of	4	180
WATSON, E. B., Some Aspects of Diesel Cylinder Lubrication	4	180
WELLONS, FRANK W., Discussion of Wilcock, Donald F., and Jones, Frederick C., Paper	4	184
What Lubrication Means to Management, GRANVILLE M. READ	3	122
WILCOCK, DONALD F., Biography of	3	129
WILCOCK, DONALD F. and JONES, FREDERICK C., Improved High-Speed Roller Bearings	3	129

Z

ZISMAN, W. A., Biography of	5	231
Zisman, W. A.—See Murphy, C. M.	6	264

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A.S.L.E. Certificate 291
A.S.L.E. Convention and Exhibit (1950) 301-3-5
A.S.L.E. Publications 301-2-5-7
Acheson Colloids Corp. 261
Alemite 254
Bowser, Inc. 301
Burns Laboratories, Inc. 308
Cincinnati Milling Machine Co. 256
Classified 308
Cuno Engineering Corp. 257
Dow Corning Corp. 305
Farval Corporation, The ..... Inside Back Cover
Grafo Colloids Corporation 304
Hodson Corporation, The ..... Back Cover
Honan-Crane Corp. 302-3
Lincoln Engineering Co. 260
Madison-Kipp Corporation 258
Manzel, Inc. 299
Morgan Construction Co. 255
Norgren, C. A., Co. 303
Oronite Chemical Company 296
Penn-Petroleum Corporation 304
Shell Oil Company, Inc. 300
Sinclair Refining Co. 307
Stuart, D. A., Oil Co., Ltd. 253
Sun Oil Company 259
Tide Water Associated Oil Co. 262
Trabon Engineering Corporation ..... Inside Front Cover
Trico Fuse Mfg. Co. 302

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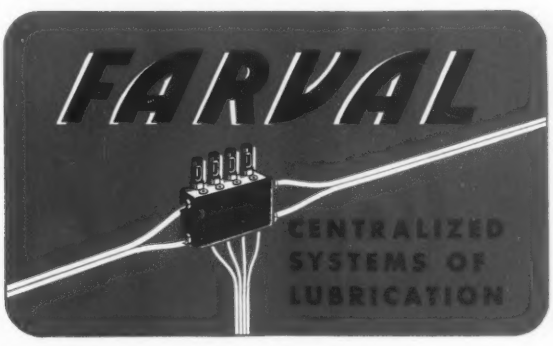

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